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"A true surgeon is never fearless He fears for his patients, he fears for his shortcomings, his own mistakes, but he never fears for himself or his professional reputation"

Samuel J. Mixter.

Emergency Surgery

By

HAMILTON BAILEY, F.R.C.S. (Eng.), F.A.C.S., F.R.S.E.

Emeritus Surgeon, Royal Northern Hospital, London; Consulting Surgeon, the Italian Hospital; General Surgeon, Metropolitan Ear, Nose and Throat Hospital; Vice-President of the International College of Surgeons; formerly Hunterian Professor, Royal College of Surgeons of England, and External Examiner in Surgery, University of Bristol

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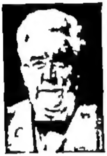

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ERNEST CHARLES LINDSAY (1883–1943) C.B.E., B.Sc., M.B., Ch.B., F.R.C.S., Surgeon, The London Hospital.

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SIR HUMPHRY ROLLESTON, Bt. (1862–1944) G.C.V.O., K.C.B., M.D., F.R.C.P., Physician, St. George's Hospital, London. President of the Royal College of Physicians, 1922–1926. (*Medicine.*)

WILLIAM WRIGHT (1874–1937) D.Sc., M.B., Ch.B., F.R.C.S., Professor of Anatomy, University of London and Dean of The London Hospital Medical College. (*Anatomy.*)

this work is dedicated in token of gratitude

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James Sherren

H. M. Turnbull

Sir James Walton

Edward Deanesly

W. Thelwall Thomas

T. C. Litler-Jones

Sir Robert Kelly

Frank Jeans

PREFACE TO THE SEVENTH EDITION

SURGICAL emergencies arise at any hour. Especially at night such emergencies are wont to fall to the lot of a junior surgeon. Obviously well-indexed reliable information on each and all of the contingencies that may be encountered in this way should be right to hand.

With this beacon light before me *Emergency Surgery* has been revised most thoroughly. It will be noticed that in this edition more space has been allocated to diagnosis and differential diagnosis than before but as in former editions, emphasis is still on treatment, and when an urgent operation is required with but few exceptions one method only of performing it is described.

From the very inception of this work I have been conscious of the great responsibility entailed in presuming to write upon a subject where the information given so often determines whether the patient lives or dies, and I am deeply indebted to all those who have contributed in writing revising or collaborating in the revision of various chapters, as well as for the helpful suggestions from proof readers. Individual acknowledgements will be found on pp. xi and xii.

Excerpts from the literature too recent to be included in the main part of the book have been included in an APPENDIX as have also a few alternative methods of treatment.

Because there are excellent books devoted entirely to fractures and their treatment, *closed* fractures of the extremities are not considered, for every general surgeon should possess at least one of these monographs.

Mr John Wright, the grandson of the founder of the firm, who saw the first edition of *Emergency Surgery* through the press, has continued to advise ever since especially in the matter of the reproduction of illustrations. This edition of the book has been piloted through the press by his co-Director Mr L. G Owens, B.Sc. and his patience, as well as his expert knowledge, are reflected on almost every page. Even those unschooled in Publishing make-up can, if they look for it, see this skill. I can assure the reader that illustrations falling near the printed matter they concern do not just happen!

It is interesting to know that for generations this publishing firm has had its own printing works (which is exceptional for medical publishers in this country and indeed the whole world) in the same building as the publishing offices, and that the printing is under the direction of Mr Philip Wright, the son of Mr John Wright.

It is thanks to my wife who has typed every word of every edition kept my case index in order and helped me to construct many of the composite photographs, that this book has reached its present state.

It is my earnest hope that those who are called upon to diagnose and to treat surgical emergencies will find in these pages what they require. In the past reviewers from many parts of the world have not only been kind—they have been *helpful*. The only adverse criticism is that a very few have suggested that almost as much space is devoted to rare as to common conditions. To this I reply that in some instances rarities in one part of the

world sometimes are not so rare in another but I do wish to emphasize that even those who are fully experienced require guidance from a book when they encounter an unusual condition.

Finally every emergency surgeon must realize that the omnipotent Reaper who eventually garners us all stands near at hand more often than in any other branch of medicine or surgery Disappointments therefore are many and some of them are inevitable Notwithstanding its manifold tribulations, it is my belief that there is no career that brings greater satisfaction and more lasting interest than that which is reflected in the pages of this book.

HAMILTON BAILEY

June 1958

FROM THE PREFACES TO PREVIOUS EDITIONS

WHILE writing the present volume I have pictured a patient stricken with an acute surgical emergency and the comparatively isolated surgeon called upon to carry out appropriate treatment. Should these pages help the latter to save the former their main object will be fulfilled.

When to operate, when not to operate, and how to operate under emergency conditions is the theme of this work.

The teachings of my Masters are its foundations practical experience gained in widely separated centres is its scaffolding while the building material comes from my case index Most of the sections of the text are founded upon personal experience all are supported by a study of the literature

ACKNOWLEDGEMENTS

For Writing Chapters

RICHARD FRANCIS WILLIAM KINKEAD ALLEN, M.D. (Dubl.), M.A.O., F.R.C.O.G., F.I.C.S. *Formerly Civil Surgeon and Superintendent, Medical School, Nagpur*

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A. BRACKEN, B.Sc., Ph.D., F.R.I.C. *Senior Scientist, British Oxygen Research and Development Ltd.*

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Acute Non-specific Infections—112.

DENNIS WALKER, M.B., B.S. (Lond.), F.R.C.S. (Eng.). *Consultant Orthopaedic Surgeon, Ashford Hospital, Middlesex*

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WRAY ELLIS, M.B., Ch.B. (Liverpool) *Orthopaedic Registrar, Bootle Hospital, Liverpool.*
GORDON EUVYEAN HEARD B.Sc., M.B., Ch.B. (Wales), F.R.C.S. (Eng.). *Registrar Professorial Surgical Unit Cardiff*
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SAMUEL MOVERS, M.B. Ch.B. (Witwatersrand) *Surgical Registrar Birmingham Accident Hospital, Birmingham*
WILLIAM FARQUHAR WALKER, M.B., Ch.B. (St. Andrews) F.R.C.S. (Eng.) F.R.C.S. (Edin.). *Lecturer in Surgery Queen's College, Dundee.*

For Reading a Large Number of the Proofs

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JOHN ALAN EAST B.Sc., M.B., B.S. (Lond.), F.R.C.S. (Eng.) F.I.C.S. *Consultant Surgeon, All Saints Hospital, Chatham.*

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T. JOHN SHIELDS. *Librarian, British Medical Association.*

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THE SPINE, THE HEAD, AND THE NECK

THE EXTREMITIES

EMERGENCY SURGERY

CHAPTER I

ARMAMENTARIUM

Suppress every manœuvre and every instrument which is not absolutely indispensable (Doyen.)

FEW suggestions only will be put forward on this subject, as the surgeon will use the instruments with which he has become familiar at his teaching school, and will gradually modify these to meet his particular requirements. An endeavour should always be made to use as few instruments as is compatible with efficiency

Fig 1.—Spencer Wells forceps (author pattern) These will be referred to in the text as long and short hæmostats.

Spencer Wells Forceps.—Spencer Wells forceps, for the sake of convenience will be described as hæmostats in the chapters which follow The pattern of the forceps which is illustrated throughout this work has a gentle curve on the flat and a tapering point. The ratchet has four teeth. They are of two sizes (*Fig* 1) These will later be referred to as the long and short hæmostats.

When operating it is well to avoid an accumulation of instruments on the towels about the wound a disorderly mass of tangled instruments on the towels which cover the patient's thighs is too often seen. Great help in keeping a clear and orderly field is to have a little bracket table which is lowered over the patient's legs when everything is in readiness for the operation (*Fig* 2). This table is reserved entirely for Spencer Wells forceps. On the near side are the short hæmostats and on the far side the long hæmostats. The surgeon picks them off the table himself. In general the operation will proceed in a more orderly fashion if bleeding points are ligated as they occur After each bleeding point has been tied off the assistant should return the hæmostat to the special table and should not leave it lying on the towels.

Fig. 2.—Bracket table for the use of Spencer Wells forceps alone The short hæmostats are on the near side During the operation the table overlies the patient legs.

Retractors.—

London Hospital retractors (*Fig* 3) will be seen in use in several of the illustrations in this work. These retractors are made in two sizes, large and small.

Wound Hooks (*Fig* 4)—A pair of large wound hooks (Liverpool pattern) are very useful, and are referred to at some length in the section dealing with the upper midline abdominal incision.

Fig. 3.—Retractor (London Hospital pattern)

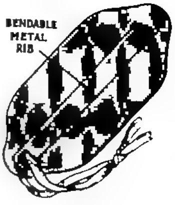


Fig. 6.—McNealy's rubber guard.

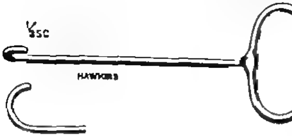


Fig. 4.—Abdominal wound hooks (Liverpool pattern)

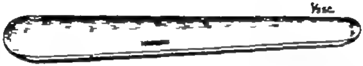


Fig. 5.—Sargent's depressor

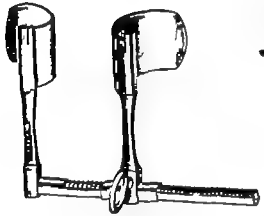


Fig. 7.—A universal mechanical retractor (author's pattern). Blades of various sizes are interchangeable

Fig. 8.—Jeans' dissecting forceps.

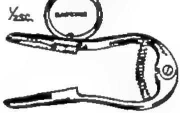


Fig. 13.—Pretty needle-holder as modified by the author

Fig. 9.—Walton's model of Watson Cheyne dissector

Fig. 10.—Denis Browne gland holding forceps.

Fig. 11.—Wayne Babcock tissue forceps.

Sargent's depressor (*Fig* 5) is almost an indispensable instrument. The uses to w
It may be put are legion. Many references will be made to it in the text.

McNealy's rubber guard (*Fig* 6) is valuable for keeping the intestines within
abdomen while the edges of the peritoneum are being approximated.

The mechanical retractor shown in *Fig* 7 is of great service. It can be used as a
spreader and is very effective in a lumbar kidney wound in addition to its duties in th
anterior abdominal wall.

Dissecting Forceps.—Jeans pattern (*Fig* 8) combines strength with delicacy. Of sub-
stantial proportions the large holes help to make the instrument comparatively light to handle.

Walton's Model of Watson Cheyne's Dissector (*Fig* 9) is a handy instrument with
many uses. There is a dissector at one end and a probe at the other. The fluted handle
may be passed beneath a large vein or tendinous structure (as for example the inner
end of the inguinal ligament in Hey Groves's operation) prior to its ligation or division
as the case may be.

Denis Browne's Gland holding Forceps (*Fig* 10) are well worth a place in the surgeon's
bag. Used very lightly without closing the ratchet they can be employed to deliver the
caecum. They are excellent lung holding forceps, and can be adapted for other purposes, e.g., removing gall-stones from the gall-bladder.

Wayne Babcock's Tissue Forceps (*Fig* 11) are extremely atraumatic and are used to grasp friable structures.

Lahey's Swab.—A piece of gauze $2\frac{1}{2} \times 1\frac{1}{2}$ in (6×4 cm.) is cut from an ordinary flat

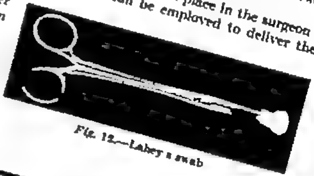
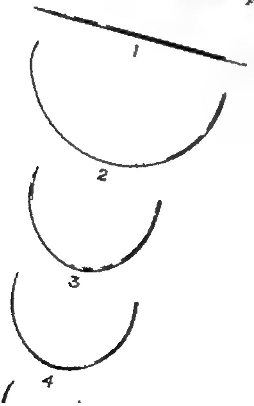


Fig. 12.—Lahey's swab



a Emesay buttons with squares of petroleum jelly gauze beneath each button (*Fig* 20). If the petroleum jelly gauze or several layers of tulle gras are not used the buttons tend to cause skin necrosis.

b Mattress sutures, combined with accurately cut pieces of ⅛-in. (3-mm.) rubber tubing inserted as shown in *Fig* 21. These are very efficient, and can be recommended in those cases where the surgeon feels that additional support to the wound is desirable

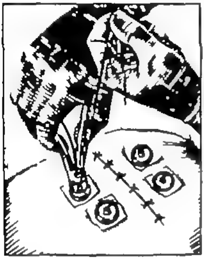


Fig 20.—Emesay buttons being used for retaining sutures in place. Note the squares of petroleum-jelly gauze beneath the buttons.

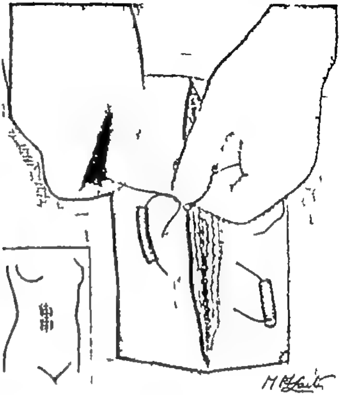


Fig 21.—Method of inserting mattress sutures so that rubber tubing lies parallel to the skin incision and not across it

Skin Sutures.—Black cotton is excellent material for suturing the skin; alternatively silkworm gut, silk, or nylon can be used.

SWABS AND ABDOMINAL PACKS

No small swab should ever enter the abdominal cavity unless it is mounted on a holder.

Abdominal Packs.—There is no universal system for counting abdominal packs, which is a great pity. Every hospital staff has its own ideas. In many hospitals a metal tag is sewn into one corner of each pack (*Fig* 22) so that should an error be committed the fact that the pack has been left inside the patient can be verified by radiography. This is a good precaution, and a negative X-ray examination has many times proved a solace to troubled minds. In some hospitals there is an excellent system whereby when the soiled packs are discarded they are hung upon a rack where they can be seen clearly. To use only large packs, with tapes attached and to have them bundled in groups of four (*Fig* 23) is a good practice.

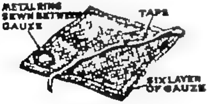


Fig 22.—Abdominal pack.

The reader is exhorted to school himself to remember that counting abdominal packs and receiving a report that they are correct before closing the abdomen or any other incision where packs have been used in the course of an operation should become an integral part of his routine. Thus, this important question w[illegible]omatically even when he is jaded—for instance, after having been called to o[illegible] middle of the night.

Standing Orders regarding Swabs at the Royal Northern Hospital

No small swabs may be loose in the theatre after the peritoneum has been opened but must always be mounted on swab-holders. Larger swabs, used for packing purposes, done up in bundles of four must be counted on the special dressings table and as each set is given out the number is recorded on a slate. All swabs after use must be put into a tray under the operating table and counted by the operating table nurse in the presence of the surgeon before the peritoneum is closed. None of these swabs, whether used or unused, must be removed from the theatre until the wound is closed and until their number has been verified as agreeing with the number recorded on the slate.

The sister or nurse responsible for the counting of swabs must have satisfied herself that the counting is correct at the completion of the operation, and before the peritoneum is closed must call to the surgeon, "Swabs correct" without the surgeon asking whether or not this is the case.

Fig 23.—Method of recording abdominal packs used during the operation

CHAPTER II

CANNULIZATION FOR INFUSION AND TRANSFUSION

For an emergency surgeon there is hardly a more important accomplishment than to be able to cannulize a radicle of the venous system expeditiously and effectively

In every walk of life skilled technicians take pride in their tools. The tools for tying a cannula into a vein are few and simple, yet in some hospitals relatively large hæmostats and clumsy toothed dissecting forceps are put out for this delicate operation.

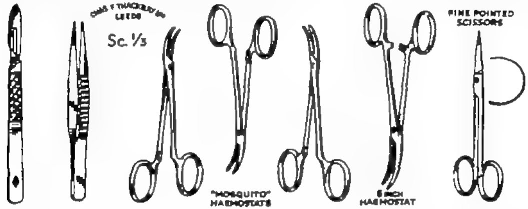


Fig 24 —Instruments for cutting down upon a vein in order to tie in a cannula. The rather larger hæmostat is used for clearing the vein from subcutaneous tissues in the manner shown in *Fig.* 32.

The essential equipment is shown in *Fig* 24 It includes three pairs of really delicate hæmostats—the so-called mosquito type is ideal. The only other indispensable instrument is a pair of dissecting forceps with fine serrated points. Really fine-pointed scissors that cut at the points are most desirable.

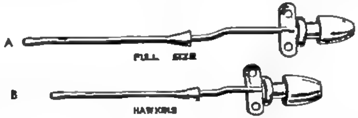


Fig 25.—Vein cannulæ A, Hamilton Bailey gold plated cannula B Hamilton Bailey's child model.

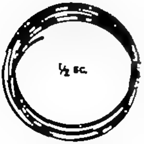


Fig 26.—Polythene tubing for cannulizing a vein.

The Cannula (*Fig* 25) is a most important item. Gold plated cannulæ will be found eminently suitable the child's model can be used with advantage for small veins in an adult. To be regularly in service a gold-plated cannula must be replated from time to time and after use it is necessary to see that blood-clot is removed from its lumen before it is put away

Polythene Tubing (*Fig* 26).—A most suitable cannula can be made by mounting a length (usually about a foot (30 cm.)) of polythene tubing on a hollow needle, which has been sawn off by a metal file ¾ in (18 mm.) from its shoulder The hollow needle must, of course be of such a size to fit the tube tightly otherwise leakage will occur at the junction.

Standard[1] Polythene Tubing

No.	Internal Diameter	Wall Thickness	External Diameter	Lumen Fitted by Needle
1	0.5 mm.	0.25 mm.	1.0 mm.	23 S.W.G.
2.	1.0 mm.	0.25 mm.	1.5 mm.	19 S.W.G.
3.	1.5 mm.	0.5 mm.	2.5 mm.	17 S.W.G.
4.	2.0 mm.	0.5 mm.	3.0 mm.	14 S.W.G.

In practice No. 2 is the size which will be required most often for veins of the forearm. The tubing with its attached needle (*Fig.* 27), is sterilized by boiling for fifteen minutes. It is essential that the lumen should be full of water at the time of the boiling [2]

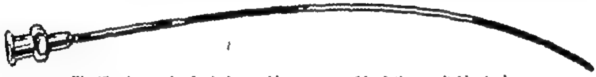


Fig. 27.—A cannula of polythene tubing constructed by fitting a suitably-sized, sawn off hollow needle into the butt end of the tubing

consequently before sterilizing water must be injected into the lumen of the tubing by means of a hypodermic syringe. After boiling rapid cooling is necessary to restore the required stiffness of the tube. Polythene tubing must not be autoclaved. This form of tubing is believed to reduce the incidence of thrombosis and phlebitis, but no conclusive proof of this has yet been forthcoming.

Flexible Nylon Tubing is an alternative to polythene tubing. Its great advantage is that it can be sterilized by autoclaving as well as by boiling. It is only a little less flexible than polythene.

An Interceptor (*Fig.* 28) is an integral part of the armamentarium. Laurie's drip bulb (*Fig.* 28 A) is a good pattern. My interceptor (*Fig.* 28 B) has the advantage that very

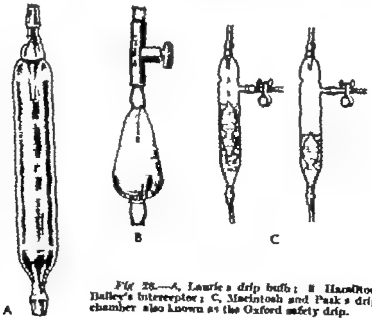


Fig. 28.—A, Laurie's drip bulb; B Hamilton Bailey's interceptor; C, Macintosh and Pask's drip chamber also known as the Oxford safety drip.

[1] Allen & Hanburys Ltd., Bethnal Green, London, E.1

[2] This is the only safe method of sterilizing polythene tubing as usually supplied, and the details should be observed with especial care. Several cases of septicaemia following inefficient sterilization of polythene tubing have been reported.

CHAPTER II

CANNULIZATION FOR INFUSION AND TRANSFUSION

For an emergency surgeon there is hardly a more important accomplishment than to be able to cannulize a radicle of the venous system expeditiously and effectively

In every walk of life skilled technicians take pride in their tools. The tools for tying a cannula into a vein are few and simple yet in some hospitals relatively large hæmostats and clumsy toothed dissecting forceps are put out for this delicate operation.

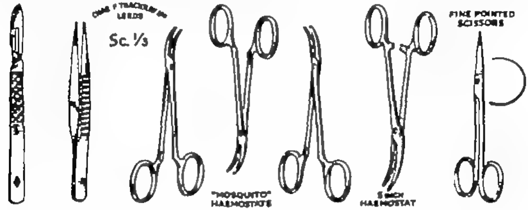


Fig 24.—Instruments for cutting down upon a vein in order to tie in a cannula. The rather larger hæmostat is used for clearing the vein from subcutaneous tissues in the manner shown in *Fig.* 83.

The essential equipment is shown in *Fig* 24 It includes three pairs of really delicate hæmostats—the so-called mosquito type is ideal The only other indispensable instrument is a pair of dissecting forceps with fine serrated points. Really fine-pointed scissors that cut at the points are most desirable

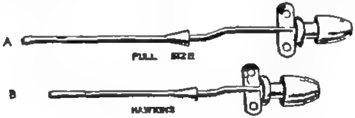


Fig 25.—Vein cannulæ A, Hamilton Bailey gold plated cannula B, Hamilton Bailey's child's model.

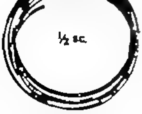


Fig 26.—Polythene tubing for cannulating veins.

The Cannula (*Fig* 25) is a most important item. Gold plated cannulæ will be found eminently suitable the child's model can be used with advantage for small veins in an adult To be regularly in service a gold plated cannula must be replated from time to time and after use it is necessary to see that blood-clot is removed from its lumen before it is put away

Polythene Tubing (*Fig* 26).—A most suitable cannula can be made by mounting a length (usually about a foot (30 cm.)) of polythene tubing on a hollow needle which has been sawn off by a metal file ¾ in. (18 mm.) from its shoulder The hollow needle must of course be of such a size to fit the tube tightly otherwise leakage will occur at the junction.

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4	2·0 mm.	0·5 mm.	3·0 mm.	14 S.W.G

In practice No. 2 is the size which will be required most often for veins of the forearm

The tubing with its attached needle (*Fig* 27), is sterilized by boiling for fifteen minutes. It is essential that the lumen should be full of water at the time of the boiling[2]

Fig 27.—A cannula of polythene tubing constructed by fitting a suitably-sized, sawn off, hollow needle into the butt end of the tubing

consequently before sterilizing, water must be injected into the lumen of the tubing by means of a hypodermic syringe. After boiling, rapid cooling is necessary to restore the required stiffness of the tube. Polythene tubing must not be autoclaved. This form of tubing is believed to reduce the incidence of thrombosis and phlebitis, but no conclusive proof of this has yet been forthcoming

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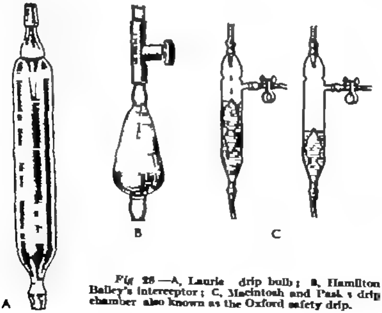

Fig 28.—A, Laurie's drip bulb; B, Hamilton Bailey's interceptor; C, Macintosh and Pask's drip chamber also known as the Oxford safety drip.

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[1] Allen & Hanburys Ltd., Bethnal Green, London, E.1

[2] This is the only safe method of sterilizing polythene tubing as usually supplied, and the details should be observed with especial care Several cases of septicæmia following inefficient sterilization of polythene tubing have been reported.

accurate dosage is possible if the correct (thick) latex rubber tubing is employed and the fine milled screw is not allowed to corrode the dosage can be so accurate as to enable one to differentiate between 25 and 30 drops per minute Macintosh and Pask's drip chamber (*Fig* 28 C) was designed to obviate the danger of air embolus should the flask be allowed to run dry

For various reasons the interceptor may become filled with fluid and the fall of the drops obscured. This is a constant source of trouble There is no need to dismantle the apparatus—the drip chamber can be cleared by passing a long hollow needle through the tube into the drip chamber as shown in *Fig* 29

The Screw Clamp.—To minimize the risk of air embolism the screw clamp should always be placed low on the tubing i.e. comparatively near the needle or cannula (*see Fig* 36, p 12)

Fig 29 —Clearing an over full drip chamber The needle is passed through the tubing until its point can be seen within the glass. By means of a hypodermic syringe air is injected and enough fluid displaced for the drip to be seen.

Choice of a Vein.—The veins of the arm provide avenues for infusion and transfusion in 90 per cent of cases. Unless a patient is collapsed and a vein is difficult to locate it is best not to select a large vein one just a little larger than the cannula or needle is most suitable For this reason, although prominent veins at the elbow are inviting the tendency should be to employ one of the veins of the forearm (*Fig* 30) Cannulization of a vein of the forearm will therefore be considered first and other sites discussed afterwards.

Technique of Inserting a Cannula.—In the case of the upper limb (high cephalic vein cannulization excepted) the delicate efficient self releasing tourniquet shown in *Fig* 31 made in a few moments from a length of ⅛ in. (3-mm.) drainage tube and adhesive plaster is ideal for applying the necessary constriction. A vein tourniquet being in place venous blood is milked upward so as to make the veins prominent (*Fig* 32) In a conscious patient the overlying skin is anæsthetized by injecting a few minims of 1 per cent procaine A short transverse incision is made over the vein, and the beak of a small hæmostat introduced into the wound, and its jaws are opened widely (*Fig* 33) When this manœuvre has been carried out three or four times the vein will be cleared from the subcutaneous tissues better than by a painstaking dissection, and there is no fear of tearing even a delicate vein. The entire circumference of the vein must be freed over a distance of about 1 cm. Two fine cotton ligatures[1] are passed beneath the vein. There is no need to use an aneurysm needle the beak of the

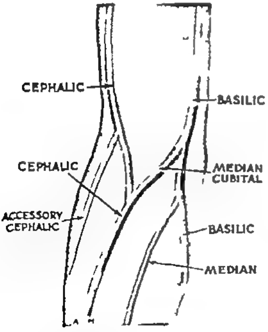


Fig 30 —The veins of the forearm.

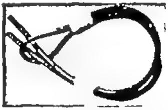


Fig 31 —Pattern of vein tourniquet recommended.

[1] Fine cotton or silk is recommended for ligation of the vein, because catgut sutures tend to loosen after a few days and allow leakage of fluid from the vein.

hæmostat is passed under the vein and the ligatures are grasped therewith. The distal one is tied and its ends caught in a hæmostat. Traction on the proximal ligature will prevent loss of blood when the vein is opened. The vein wall is picked up in dissecting

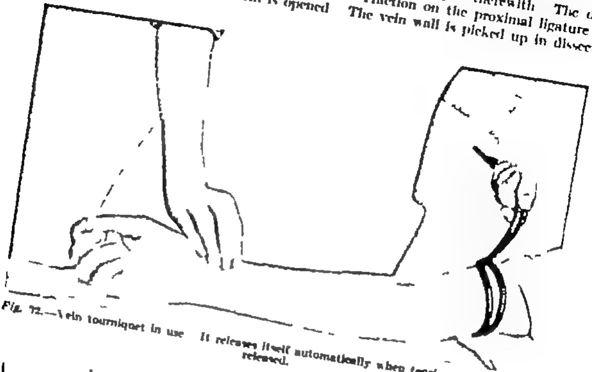


Fig. 32.—Vein tourniquet in use. It releases itself automatically when tension on the ends is released.

forceps, and with one snip of the fine-pointed scissors a triangular flap is raised (*Fig.* 34 inset). The apex of the flap is grasped in a hæmostat or by dissecting forceps (*Fig.* 34). It is recommended to flood the wound and moisten the shaft of the cannula with citrate solution before inserting the cannula into the vein. If it appears that there will be difficulty in inserting the cannula, it is a good practice to place a hæmostat on each side of the incision in the vein, but this method is impracticable unless really fine mosquito hæmostats are available. Employing this technique a cannula slightly larger than the vein can be inserted. When the cannula (through which fluid is now running) is within the lumen, the proximal ligature encircling the vein and the nozzle within is tied. It is of fundamental importance to remember that the tourniquet must be released at this juncture. Having cut the ligatures one or two skin sutures are used to close the incision about the cannula. If the gold-plated cannula has been employed, it is anchored to the skin by means of fine stitches passed through the slots at its base.

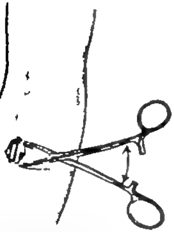


Fig. 33.—A rapid and efficient method of displaying a subcutaneous vein through a small transverse cutaneous incision.

Polythene tubing is introduced into a vein by exactly the same technique as that just described. The tubing is inserted along the vein until it meets with an obstruction; it is then withdrawn slightly. For infusion of isotonic solutions there is

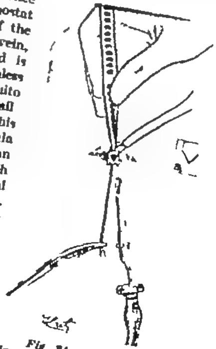


Fig. 34.—Ready for the insertion of the cannula. Inset shows the incision in the vein.

no need to insert more than about 6 in. (15 cm.) less will suffice It is an advantage to introduce the polythene tubing through a tiny separate and lower stab incision. After the proximal encircling ligature has been tied, the hub of the needle is connected with the infusion or transfusion set. The skin is then closed about the tubing which is anchored to the skin by pieces of flexible adhesive plaster (*Fig* 35) With the tubing thus securely fastened, considerable movement of the arm is possible without mechanical trauma to the vein wall.

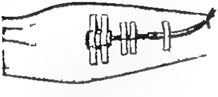


Fig 35.—Method of anchoring polythene tubing and the end of the delivery tube to the skin of the forearm.

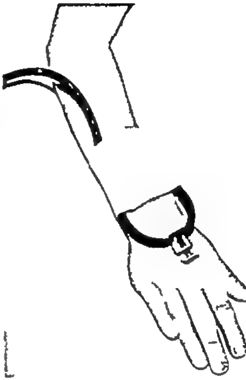


Fig 36.—A good method of immobilizing a hollow needle in a vein during continuous fluid therapy

For intermittent infusion and transfusion, after the desired amount of fluid has been gravitated into the vein, the sawn-off hollow needle is removed from the polythene tubing the free end of which is crushed with a hæmostat and flame sealed. When it is desired again to resume intravenous therapy the sealed portion is cut away with sterile scissors.

The Long Saphenous Vein at the Ankle.—Because of the liability of the veins of the lower extremity to thrombose and the resulting danger of pulmonary embolism, the long saphenous vein at the ankle—once a popular site for fluid therapy—is being used less and less, except in young children who are almost immune to these dangers. From time to time cases are encountered, especially in women and young children (but even in men), where a visible or palpable vein cannot be found in either arm. In such cases, after a light tourniquet has been applied to the thigh, the long saphenous vein invariably will be found through an appropriate incision just anterior to the medial malleolus (*Fig* 37). After picking up the skin with dissecting forceps, a transverse incision is made ¾ in. (19 mm.) above and in front of the medial malleolus. The vein lies deeply midway between the tendon of the tibialis anterior and the tip of the medial malleolus both these structures can always be palpated Even after the vein has been cannulized successfully it does not necessarily follow that in a patient with peripheral circulatory collapse the immediate flow of fluid into the saphenous vein will be satisfactory venospasm is often troublesome in this situation. When this avenue is employed the limb should not be splinted, and it is inadvisable to continue the administration of fluid into a vein of the lower limb for more than twenty four hours.

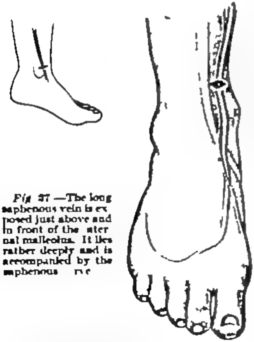


Fig 37.—The long saphenous vein is exposed just above and in front of the internal malleolus. It lies rather deeply and is accompanied by the saphenous nerve

The Cephalic Vein in the Shoulder.—In contradistinction to the foregoing site a great advantage of utilizing the proximal part of the cephalic vein is that fluid therapy can be continued, if necessary, for long periods (up to a week) with a minimum risk of thrombophlebitis. Another boon is that in peripheral circulatory collapse when all other veins of the limbs are contracted the comparative lack of musculature of the cephalic vein at this site renders it capable of the reception of viscid fluid (blood plasma) without hindrance. The only possible disappointment in employing this site is that in 5 per cent of cases the vein is absent, but seldom is the abnormality bilateral. Patients in whom the cephalic vein is absent have a small transverse subcutaneous vein crossing the shoulder. If this is present do not explore for a cephalic vein on that side. *The vein lies in the delto-pectoral groove*

Fig. 38.—Incision for displaying the cephalic vein in the delto-pectoral groove. (*N. H. Antia.*)

Fig. 39.—The cephalic vein in the delto-pectoral groove has been cannulized. The tubing of the infusion set has been secured to the arm, as shown. Note the range of movement possible without hindering the gravitation of fluid into the vein. (*N. H. Antia.*)

deep to the deep fascia. In obese subjects the lower border of the pectoralis major can be traced *to its insertion in the groove. This is facilitated by asking the patient to raise his* arm a few inches off the bed.

Technique.—An assistant stands by the head of the patient, and by gentle pressure with his index finger distends the vein by compressing it proximally in the delto-pectoral groove just below the midpoint of the clavicle. This is the key to the procedure. With the other hand the assistant retracts the upper part of the incision. After adequate cleansing and towelling and local infiltration of 1 per cent procaine a transverse incision 1 in. (2.5 cm.) in length is made over the groove at the level of the lower border of the anterior axillary fold (*Fig.* 38). The incision is deepened to the deep fascia. With adequate retraction the vein will be seen as a blue cord lying *in the groove beneath the fascia.* If in doubt about the position of the groove the patient is asked to raise the arm a few inches, and the groove is palpated with a finger in the wound. The deep fascia is incised and about half-an-inch of the vein is exposed by hæmostat dissection, in the manner described on p. 11. Cannulization with polythene tubing 2 mm. in diameter fitted to a 14 S.W.G. needle is very satisfactory, but not more than 1½ in. (3.8 cm.) must be introduced, as a longer length will become kinked when the arm is abducted. After closing the incision it is an advantage to anchor the tubing containing the shaft of the needle to the skin with a stitch. The wound is covered with a small adhesive dressing; the tubing of the infusion or transfusion set is secured to the upper arm by two narrow pieces of flexible adhesive plaster that encircle the entire limb and adhere to themselves by overlap (*Fig.* 39).

A Vein at the Back of the Hand.—In a number of instances when the veins of the dorsal arch can be rendered prominent a vein at the back of the hand can be employed satisfactorily

for an infusion or transfusion not exceeding twenty four hours, particularly if a child's cannula is available

The External Jugular Vein is seldom utilized but there is no valid reason for undue hesitation in choosing it. Especially when the patient is on the operating table the external jugular vein is often more quickly accessible than any other vein. The vein, as it crosses the sternomastoid (*Fig* 40), can be exposed easily

Fig. 40.—The external jugular vein is site of election for cannulization.

Venepuncture.—With constant practice it is possible to become so adept at venepuncture that the occasions when the vein has to be exposed by cutting down upon it are relatively infrequent. A tourniquet is tightened suitably around the upper arm. If there is one reasonably prominent a vein of the flexor surface of the forearm is selected The hollow needle is then inserted into the vein. During venepuncture one should keep a look-out for dimpling of the skin over the needle point, which occurs when the needle remains in a plane between the skin and the vein the dimpling disappears as soon as the vein is entered.

Once the wall of the vein has been pierced the bevel of the needle is rotated so that it looks downwards. The tourniquet is then removed.

Even in cases where the patient is left with fluid gravitating satisfactorily and the limb has been immobilized by a splint, it is not unusual to receive a report that the flow has ceased. In a very large percentage of cases this is due to the sharp point of the needle penetrating the vein wall from some movement of the needle however slight. This untoward happening can often be prevented by applying 3-in. (7 5-cm.) flexible adhesive plaster carefully around the limb in such a way as to include a backward curl of the attached tubing beneath the adhesive plaster (*see Fig* 80) Even if there is an inadvertent pull on the tubing the needle will not become displaced. Another good method is to employ a plaster-of Paris bandage to secure the curl of the tubing

The West Middlesex Hospital Trocar and Cannula (*Fig* 41).—To offset the advocacy of a routine practice of cutting down upon a vein it must be admitted that a vein that has been

Fig 41 —The West Middlesex vein trocar and cannula.

tied is lost as a future receptor For this reason particularly in cases where *repeated* infusions or transfusions are likely to be required, the vein trocar and cannula combines the advantages of venepuncture with those of formal cannulization The trocar and cannula can be inserted into the vein through a tiny skin incision, although the latter is not essential When the trocar is withdrawn a reasonably blunt-ended cannula is left within the lumen of the vein.

Fig 42.—Franklin Evans's intravenous needle

Franklin Evans's modification of the West Middlesex trocar and cannula makes introduction simpler The trocar is a hollow needle (*Fig* 42). If the cannula with its trocar (to which is attached a syringe half full of saline solution) is used for venepuncture one can be certain that the cannula is within the lumen of the vein before withdrawing the trocar

Introducing Polythene Tubing into a Vein via Venepuncture.—When the chosen vein is suitable for venepuncture with a large needle polythene tubing can be inserted through the needle It is stated that before sterilization by boiling :—

No 1 polythene tubing passes through a 16 S W G needle
No. 2 14 S W G
No. 3 9 S W G
No 4 6 S W G

In practice it will be found that the *internal* diameter of S W G needles made by different manufacturers varies It is only the outer diameter which is standardized Another factor to be taken into consideration is that a degree of expansion of the tubing occurs when sterilization by boiling is undertaken. For these reasons it is seldom that tubing larger than No 1 can be passed into a vein through a hollow needle

Melrose and Shackman have proved that by doubling the diameter of a needle or cannula, the maximum rate of gravitation into a vein is increased sixteen times, whereas quadrupling the head pressure only doubles the rate of flow It will be appreciated that in the case of polythene tubing the junction of the needle with the tubing seriously reduces the diameter of the channel When the diameter has been reduced by fitting a 23 S W G

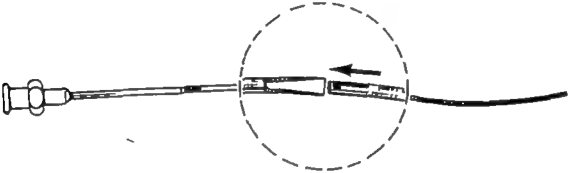


Fig. 43.—Effecting a watertight junction between No. 1 and No. 2 polythene tubing

needle to it, No. 1 polythene tubing is too fine to allow blood or plasma to gravitate freely through it. To overcome this difficulty a piece of No 2 polythene tubing about 4 in. (10 cm) long, to one end of which is fitted a No 10 S W G needle, is taken. The other end of this is bored out by rotating it on the point of a No 11 Bard Parker scalpel blade to give it a blunderbuss mouth (*Fig* 43) The end of the No 1 tubing pressed into the bored-out end of the No 2 tubing will effect a strong waterproof joint, and thus, by avoiding reducing the diameter of the No. 1 tubing, the free gravitation of viscid fluid into the vein is permitted (Macgregor).

Splintage.—Irrespective of the type of needle or cannula employed if a vein of the forearm (as opposed to a vein at the fold of the elbow) has been employed splinting is unnecessary unless the patient is restless, or liable to become so In many cases, however it is advisable to take the precaution of splinting the arm, especially if the patient has still to recover from an anæsthetic the splint can be removed when tranquillity is assured. A plaster slab padded with Gamgee tissue forms an excellent splint (*Fig* 44)

The Use of Edwards's Vein-seeker.—Edwards's vein-seeker (*Fig* 45) allows intermittent intravenous infusion without the necessity for repeated venepuncture. By sterilizing the rubber tubing between the needle and the sight-glass, the vein-seeker becomes virtually a large vein upon the surface, and into it fluid can be gravitated or injected at will. If so instructed, the night sister can give intravenous fluid to the patient.

The *technique* of inserting the vein-seeker is depicted in *Fig* 46. The instrument is 4 in. (10 cm.) long this allows the butt end of the needle to be held between the thumb and forefinger while the teat is compressed by the fourth and fifth digits against the hypothenar eminence The teat, now compressed, is empty but the rest of the instrument is still filled with citrate solution. The point of the needle is inserted under the skin where the vein is suspected and the pressure on the teat released. The teat remains collapsed until the vein is entered when the negative pressure within the teat draws blood into the instrument. When blood appears in the glass tube the whole instrument is fixed in position by two strips of adhesive plaster

By sterilising the rubber tubing between the needle and the sight-glass with spirit, the necessary injection or gravitation of fluid can be made into the rubber tubing and from thence into the venous system.

The modification of Edwards's vein-seeker illustrated in *Fig* 47 has been found extremely useful. The outfit can be improvised with materials that are not difficult to obtain. It is of cardinal importance *that the tubing be of latex rubber Some rubber tubing, particularly* that made from synthetic rubber has been found to be useless and dangerous for this purpose.

Fig 44.—To splint the arm in the posture naturally assumed is less irksome than the usual supinated position A plaster slab with a turn round the wrist has been used in this case

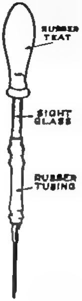


Fig 45.—Edwards vein-seeker

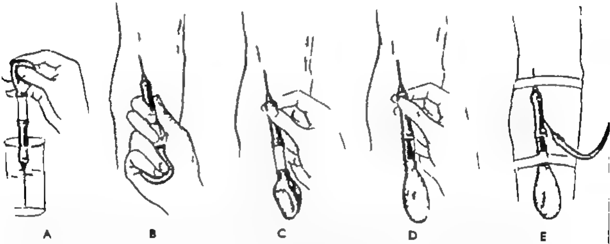


Fig 46.—A, Fill with sterile citrate solution B Hold as shown and compress the bulb. Insert the needle beneath the skin overlying the vein. C, The bulb remains collapsed. D On entering the vein the bulb expands and the sight-glass becomes filled with blood. E, The seeker is fixed in position The bulb is slightly compressed and released, to make sure that the needle is within the vein. All is in readiness for the reception of intravenous fluid.

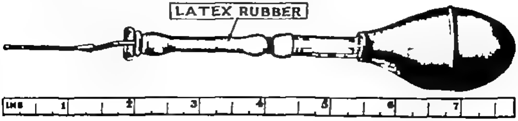


Fig 47.—The relative sizes of the components can be comprehended by referring to the scale

By sterilising the rubber tubing between the needle and the sight-glass with spirit, the necessary injection or gravitation of fluid can be made into the rubber tubing and from thence into the venous system.

The modification of Edwards's vein-seeker illustrated in *Fig.* 47 has been found extremely useful. The outfit can be improvised with materials that are not difficult to obtain. It is of cardinal importance that the tubing be of latex rubber. Some rubber tubing, particularly that made from synthetic rubber, has been found to be useless and dangerous for this purpose.

Fig. 44.—To splint the arm in the posture naturally assumed is less irksome than the usual supinated position. A plaster slab with a turn round the wrist has been used in this case.

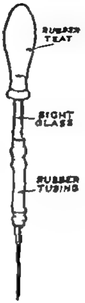


Fig. 45.—Edwards's vein-seeker.

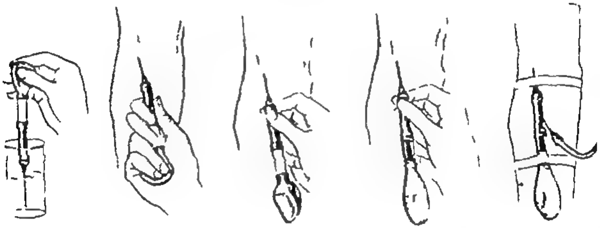


Fig. 46.—A, Fill with sterile citrate solution. B, Hold as shown and compress the bulb. Insert the needle beneath the skin overlying the vein. C, The bulb remains collapsed. D, On entering the vein the bulb expands and the sight-glass becomes filled with blood. E, The seeker is fixed in position. The bulb is slightly compressed and released, to make sure that the needle is within the vein. All is in readiness for the reception of intravenous fluid.

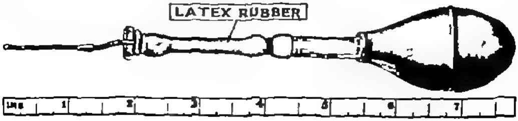


Fig. 47.—The relative sizes of the components can be comprehended by referring to the scale.

A cannula is employed because it can be indubitably tied into a vein and it withstands hazards of displacement to which experience shows it may be subjected. In short, it is almost foolproof. The bulb, tubing and cannula are filled *completely* with 3·8 per cent

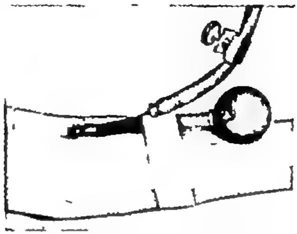


Fig. 48.—A hollow needle linked to an infusion or transfusion set can be inserted, withdrawn, and reinserted by the nurse-in-charge according to orders she has received.

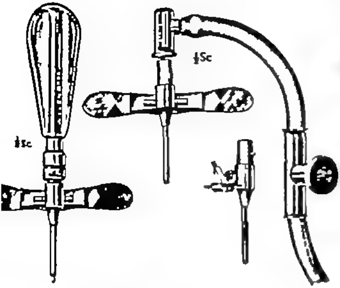
citrate solution. The cannula is tied into a vein in the usual way. The bulb is compressed slightly and released; blood appears in the glass window. Every four to six hours the bulb is *slightly* squeezed and released by the nurse in charge and through the window it is noted whether the blood moves to and fro. It is possible to keep the cannula in situ for days, ready for immediate use when required (*Fig.* 48).

CANNULIZATION OF THE BONE-MARROW

In cases of grave emergency bone-marrow is an excellent avenue for replenishment of the circulation. Swift and certain cannulization of the manubrium sterni can be carried out in a poor light and in unfavourable surroundings. It comes as a boon when the patient

Fig. 49.—Injecting plasma into the bone-marrow. One pint can be given in two or three minutes by this method.

is collapsed and the veins are imperceptible. Plasma, dextran and electrolytic solutions will *always* flow into the bone marrow and blood can *always* be injected with a syringe. Again in surgical practice there are crises where to be of value a pint (560 ml.) or more of fluid must be put into the circulation in a matter of minutes. On such occasions injection of the fluid by means of a Record syringe or syringes into the bone-marrow (*Fig.* 49) is a



A, The apparatus.

B, Employing a short and rather stout hollow needle, a weal of local anaesthesia is raised in the skin overlying the junction of the upper two-thirds and the lower third of the manubrium. The tip of the needle is then passed firmly into the periosteum, and the local anaesthetic is very forcibly injected.

C, Using even pressure, the trocar and cannula are introduced with an unhurried boring motion, at right angles to the bone. Force is unnecessary. Entry of the marrow is accompanied by an unmistakable sudden collapse of resistance.

D. The trocar is removed, and at the same time the cannula is steadied, while the wings are adjusted to lie flat on the skin.

E, The nozzle of a 10-ml. syringe, half full of citrate solution, is linked firmly with the cannula. Some citrate solution is injected. Subsequent aspiration should be accompanied by free entry of red marrow (which looks like blood) into the barrel of the syringe. This is the all-important requirement of the procedure.

F. The lumen of the adaptor attached to the infusion unit is examined and tested by allowing a little of the solution to escape. The adaptor is linked with the cannula and strips of adhesive plaster are placed to fix the wings in position. Crystalloid solutions and plasma should run into the marrow as freely as they do into a vein.

Fig. 40.

method that has yet to be bettered. By means of a sternal puncture trocar and cannula the bone-marrow can be entered with a swiftness and certainty that bedwarfs cannulization of a radicle of the venous system. Of several desperate occasions on which this expedient has been employed with unbounded satisfaction the following case will be cited —

A very difficult operation had just been concluded—the removal of a fibroneuromyxoma the size of a cricket ball from the posterior cord of the brachial plexus. After an unfortunate delay in getting ready the apparatus for infusion, it was found that saline solution would not run into the left saphenous vein. The house surgeon therefore cut down on to the right saphenous vein but the saline solution only gravitated at the rate of about twenty drops a minute So collapsed was the patient (a woman of 83) that it was useless to expect replenishment of the circulating fluid by this route A sternal puncture trocar and cannula were sterilized rapidly and the manubrium sterni was cannulized forthwith. By this time plasma was available and a pint and a quarter (700 ml.) was injected in less than two minutes. After the patient who appeared moribund, had received a pint (500 ml.) of plasma, the anæsthetist reported that the pulse was still imperceptible It was not until she had received two pints (1120 ml.) of plasma via the bone-marrow that the cannula tied into the saphenous vein began to function adequately By this time the patient was out of immediate danger

In order to make use of this route it is of course, necessary to possess a bone-marrow trocar and cannula. The pattern with adjustable wings (*Fig* 50 A) will give satisfaction. Provided the simple details given below are followed the method is foolproof Plasma and electrolytic solutions gravitate into bone-marrow with the readiness that may be compared to the flowing of such fluids into an unobstructed vein. No matter what the condition of the patient, this pleasing free flow is the same it is not affected by collapse or venospasm For blood transfusion the route is not regularly satisfactory unless the blood is injected with a syringe It is sufficient to limit the infusion by this route to twenty four hours. In a few instances the cannula has been knocked out of position by the patient or a tube connecting it to the reservoir has been subjected to a pull that has caused the cannula to become displaced When the cannula has been inserted satisfactorily it always functions. If the cannula is not inserted satisfactorily at the first attempt, and a second puncture is made, it will be found that considerable leakage of fluid occurs, the reason for this being that the fluid escapes through the perforation of the bone of the first puncture (*Fig* 51).

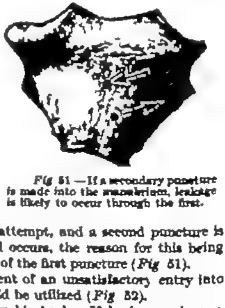


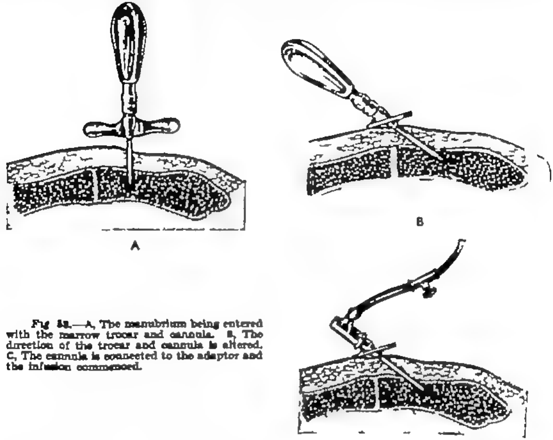
Fig 51 —If a secondary puncture is made into the manubrium, leakage is likely to occur through the first.

On this account, in the rare event of an unsatisfactory entry into the manubrium the gladiolus should be utilized (*Fig* 52).

Fig. 52.—Sites for puncture of the manubrium and the gladiolus.

Technique.—The patient lies on his back. If he is conscious, a weal of local anæsthetic is raised on the skin in the middle line just above the manubrio-gladiolar junction. Using a wide-bore but short hollow needle, its point is driven right on to the bone and about 2 ml. of 1 per cent solution of procaine is infiltrated. This subperiosteal infiltration is an important detail. The area is then massaged with a swab so as to disperse the anæsthetic and enable one to feel the manubrio-gladiolar synchondrosis. The trocar and cannula is inserted just above this ridge (*Fig* 52) and pointed almost directly downwards towards the floor but with a very slight inclination towards the patient s head. An unhurried boring motion is imparted to the instrument. The pressure, at first slight, is increased. The feeling that the outer plate has been penetrated is unmistakable Penetration being accomplished (*Fig* 53 A) the angle of the instrument is altered and the point is directed towards the patient s head (*Fig* 53 B). The trocar is removed. The next step is to take a 10- or 20-ml. Record syringe half full of 3·8 per cent sodium citrate solution, which is in readiness. The syringe is affixed to the cannula and some of the citrate solution is injected. The piston is withdrawn. If what appears to be blood (it is red marrow) is easily and liberally withdrawn so that it colours the whole of the

contents of the syringe the extremity of the cannula is placed correctly within the marrow cavity If the flow of marrow is not entirely free, the trocar is reinserted into the cannula, which is then very slightly withdrawn and another attempt to aspirate marrow is made When entry of the tip of the cannula into the marrow cavity is undeniable more citrate solution is injected. The wings of the cannula are now set at an appropriate angle and if need be, pieces of gauze are inserted beneath them Strips of adhesive plaster of an



A

B

C

Fig 53.—A, The manubrium being entered with the marrow trocar and cannula. B, The direction of the trocar and cannula is altered. C, The cannula is connected to the adaptor and the infusion commenced.

appropriate width are applied across the wings of the cannula, as can be seen in *Fig* 50, care being taken to ensure that the skin is dry so that the adhesive plaster sticks. The syringe is removed and the cannula is linked with the infusion unit (*Fig* 53 C) the tubing of which has been previously demonstrated to be free from air bubbles. Further strips of adhesive plaster are placed to steady the attached tubing at the correct angle.

Dangers and Difficulties.—The only danger is that both plates of the manubrium may be perforated and the fluid introduced into the superior mediastinum. This disaster is impossible with the apparatus depicted in this chapter provided the simple instructions detailed therein are followed.

It should be noted that there is no medulla in the sternum of a child and *this site must never be used in infants or children*

In approximately 2 per cent of cases the patient complains of a " bursting feeling " in the chest.

Osteomyelitis has not occurred in any of over 200 personal cases.

CANNULIZATION OF THE VENA CAVA

Inserting a polythene tube into the inferior ve... required when concentrated solutions of dextrose which would cause thrombo... al vein must be adminis-tered for many days, as in the ... t of renal ... It is also an excellent method for aspirating blood ... transfusion ... To minimize the risk of infection, masks, gowns, and ... be worn. The apparatus

required is the same as that for cutting down on a vein : a transfusion bottle containing the appropriate solution a polythene tube 4 mm in diameter and about 12 in (30 cm) long a short piece of thick walled rubber tubing to fit tightly over the polythene tube, and all connecting pieces (*Fig* 54). A 2 in. (5-cm.) incision exposes the upper end of the saphenous vein the three or four main tributaries and the distal end of which are ligated. The vein is opened and the polythene tube is passed for 8–10 in. and secured firmly with a double ligature of fine cotton. The following arrangements exert pressure on the wound in the vein not only while the catheter is in situ but also when the time comes for it to be removed. At the time of insertion of the catheter a stout nylon suture is passed through the skin, under the saphenous vein half an inch (12 mm.) proximal to the point of entry of the polythene tube, over the vein, and then under it once more and brought out on the skin of the opposite side. This suture is tied securely over a small pad of sterile gauze, and its ends are left long When the time comes to remove the polythene tube the nylon knot is untied as soon as the catheter is withdrawn the suture is tightened over a gauze pad, rather more firmly than before The nylon suture is removed by firm traction 72 hours later

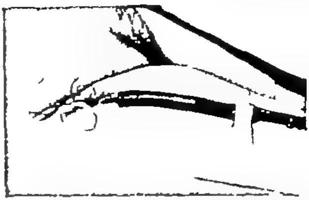


Fig 54 —Distal end of a polythene tube which was passed through the right saphenous vein into the inferior vena cava, and through which continuous infusion was maintained for 17 days without producing any complication. (C. Scott Russell and others.)

VENEPUNCTURE AND CANNULIZATION OF AN INFANT'S VEIN

Venepuncture is often practicable A vein of the hand, the cubital fossa, or the scalp is most serviceable. If the arm is used, the limb should be splinted before venepuncture is attempted. In infants, for more rapid infusion of small amounts, percutaneous puncture of a vein of the scalp is employed. The side of the scalp is shaved and one of the tributaries of the superficial temporal vein is chosen the head must be held firmly by an assistant throughout the procedure. Puncture having been effected, the fluid is introduced preferably with a Kaufmann s two-way syringe (*Fig* 55) On no account whatsoever should the superior longitudinal sinus be employed for the administration of fluids.

Fig 55.—Kaufmann s two-way syringe

Cannulization.—Cutting down on a vein under local anaesthesia is necessary when the veins are collapsed, the baby is fat, or percutaneous puncture has failed.

The standard vein to cannulise in an infant is the long saphenous vein at the ankle. Occasionally a vein in the antecubital fossa can be used but successful exposure is uncertain, especially in fat babies. For difficult cases the long saphenous vein in the middle of the thigh is recommended. First, the technique of cannulizing the long saphenous vein at the ankle will be described.

Splinting the Lower Limb is a highly important consideration It should be done as a first step, not after the cannulization. Immobilization of an infant s leg is without the dangers attendant upon immobilization of an adult s leg (see p 12)

A narrow straight wooden splint that will extend from above the knee and project beyond the foot for at least 8 in. (20 cm.) is required. Its width should be just a little greater than the diameter of the infant s calf The splint should be padded but only sparsely Half-inch (1 25-cm.) adhesive plaster (not flexible adhesive plaster) must be at hand. Fix the leg to the splint in the manner shown in *Fig* 56. Note that the foot is held in slight plantar flexion, and that the two strips of plaster that maintain this position are applied very firmly The strip of adhesive plaster around the upper part of the calf is also firmly applied but not so tight as to compress the saphenous vein. Having applied the splint, sterilize the skin in the region of the ankle with ether and alcohol, cover the area with a sterile towel and let the

infant rest while everything that will be required is brought to the scene of the operation. When possible, this operation is better done in the operating theatre where good lighting is assured, and crouching over the infant's cot is obviated.

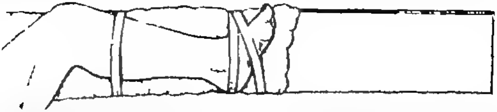


Fig. 56.—Method of splinting an infant's leg prior to cannulization of the saphenous vein at the ankle. (*After MacCarthy.*) Alternatively a lead splint is malleable and provides excellent immobilization.

The exposure of the long saphenous vein[1] in an infant differs in no essential particulars from that described on p. 12. It is advisable to inject the local anæsthetic not only superficially, but more deeply, because the œdema thus produced enables the operator to distinguish the blue-coloured vein more easily. For tying a cannula in place, fine cotton sutures are recommended. The vein is opened by an oblique cut with scissors. This is the crux of the operation: the cut must be large enough to admit the cannula, but restrained enough to prevent severing the vein. To leave the stylet projecting from the cannula is a good expedient: the stylet is introduced, and the shank of the needle follows. The suture is tied above the bulbous knob on the shank (*Fig.* 57) and the stylet is withdrawn. Alternatively, No. 1 polythene tubing

Fig. 57.—Hamilton Bailey's infant cannula.

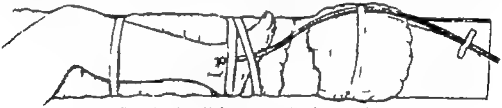


Fig. 58.—Cannulization of infant's internal saphenous vein. Final arrangement of the splint and the tubing. (*After MacCarthy.*)

can be used to cannulize the vein. If an entry into the lumen of the vein has been effected, assuredly a hypodermic syringeful of saline solution can be injected with the lightest pressure on the plunger. Only then is the cannula linked with the infusion unit. It is gratifying to observe a steady drip through the interceptor and no rising of the skin in the neighbourhood of the incision. A superficial skin stitch is placed so that, when it is tied, it will hold the expanded base of the cannula directly in the line of the vein. If this stitch is properly placed and firmly tied, the cannula cannot move. One mattress stitch, so placed as to coapt the lower to the upper lip of the incision, completes the operation (*Fig.* 58).

The Long Saphenous Vein at the Middle of the Thigh (*Fig.* 59) is an excellent site for cannulization in cases when the patient is very collapsed, and consequently venospasm is expected, or when an infant cannula or fine polythene tubing are lacking. The vein at this site will accommodate an adult size cannula.

Fig. 59.—Exposure of the long saphenous vein in the middle of an infant's thigh.

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[1] The cuff of a sphygmomanometer placed around the thigh and inflated to about 45 mm. Hg for a few minutes, by causing the vein to become distended, facilitates this procedure.

[2] Made by Down Bros. Ltd., 23, Weymouth Street, London, W. 1.

CANNULIZATION OF THE BONE-MARROW IN INFANTS AND YOUNG CHILDREN

This procedure carries the risk of causing osteomyelitis, but if prophylactic penicillin therapy is given the incidence of the complication is small. Nevertheless cannulization of the bone marrow should not be undertaken lightly. If the water and electrolytic requirements of the patient can be met by means of subcutaneous infusion combined with hyaluronidase (see p. 30) the method is superfluous. On the other hand occasions arise when the administration of plasma is essential, but for one reason or another the intravenous route is impracticable: this is the occasion when cannulization of the bone-marrow of the tibia may prove a life-saving measure. The slow and uncertain rate of flow does not justify this route for blood transfusion (Wilkinson).

Technique.—Because of the danger of introducing organisms into the bone the procedure is best carried out in the operating theatre. The skin overlying the bone is sterilized most thoroughly. The procedure is simple. It can be accomplished with a large-bore hollow needle but one of the special trocars and cannulæ designed for the purpose (*Fig.* 60) is most

Fig. 60.—Thompson's trocar and cannula for tibial marrow infusion of infants.

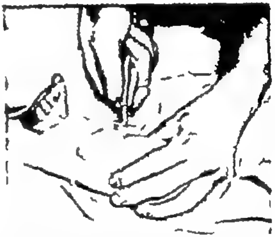

Fig. 61.—The tibial marrow must be cannulized at right angles to the subcutaneous surface of the tibia in its upper third.

desirable. The site chosen is the flat subcutaneous surface of the tibia 1 in. (2·5 cm.) below the level of the tibial tuberosity (*Fig.* 61). The trocar and cannula must be inserted at right angles to the surface of the tibia. The limb, therefore must be rotated externally to ensure that the flat surface looks directly upwards.

Special Nursing Instruction.—The limb should be watched for œdema. After initial slowness, there is a tendency for the drip to speed up and run too fast. Another cause of œdema is the cannula becoming loose, and consequently the fluid escaping into the subcutaneous tissues.

CANNULIZATION IN THE NEWBORN

Cannulization of the Umbilical Vein.—Everyone in the room must wear a mask. It is of great assistance to have the infant bandaged to a cruciate frame (see *Fig.* 629 p. 467) for this procedure. The abdominal wall and the umbilical cord are swabbed with a skin antiseptic and the baby is covered with a sterile towel in the centre of which is a small hole. The stump of the umbilical cord is brought through the hole and is divided with a scalpel ¾ in. (2 cm.) from the abdominal wall. Sterile gauze is then packed around the cord.

Usually there is but little bleeding from the umbilical vein and a negligible amount from the umbilical arteries. On the other hand, if the infant is cyanotic, blood pours from the umbilical vein which lies in the upper part of the umbilical cord: a certain amount of loss in this way benefits the infant by relieving congestion. The vein wall is grasped in hæmostats at two points opposite one another and a closed third hæmostat is used to dilate the vein to a point beyond the junction of the cord with skin: the polythene tubing is then introduced into the vein. Sometimes an obstruction is met almost immediately. If this is so the tubing must be removed and the umbilical cord shortened still farther. If necessary only a few mm. of cord need be left, and a catgut stitch will close it when

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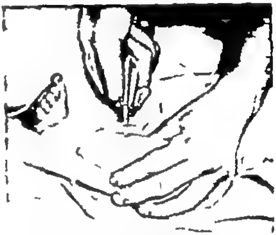

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it is no longer needed for infusion or transfusion. The next situation at which tubing is liable to become obstructed is at the level of the skin. Slight pressure on the tip of the tubing from without will help it to pass onwards. Once the tip of the tubing is within the abdominal wall the stump of the umbilical cord should be pulled towards the pubis. After a trial in passing the tube at different angles, it will pass readily for a further 2 in. (5 cm.) If not, arrest of the tubing can often be overcome by rotating it. During the passage of the tubing the assistant applies syringe suction to the end of the tube, to free its lumen from newly formed clot. At about this distance the tip of the tubing enters a branch of the portal vein and because of the calibre of the branch, if such is applied to the tubing with a syringe blood does not flow freely An endeavour should be made to pass the tubing still farther Occasionally it can be made to pass about 4 in. (10 cm.) a sign that it has negotiated the ductus venosus and has entered the inferior vena cava. If it cannot be made to pass farther than 3 in. (7 5 cm.), and blood cannot be aspirated, try withdrawing the tube a short distance, and apply suction again. If still unsuccessful, the explanation is that the tubing is blocked with blood-clot therefore withdraw the tubing completely and start again with a fresh piece of tubing When the umbilical vein has been cannulized successfully (*Fig* 62) blood can be aspirated easily through the tubing but the suction must be gentle or it will cause the vein walls to collapse Once in place satisfactorily a cotton ligature is tied around the umbilical vein to keep the tubing in place, and the proximal end of the tube is connected to an infusion or transfusion set in the usual manner

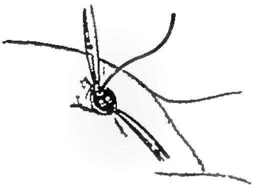

Fig 62.—When the umbilical vein has been cannulized successfully blood rises in the polythene tubing, and the venous pressure can be measured thereby

While polythene tubing is usually recommended for this procedure, an ordinary metal cannula tied into the vein acts admirably

Danger: Perforation of the umbilical vein has been reported on several occasions. Always employ blunt-ended tubing and, provided gentleness is exercised, this complication cannot occur

The usual limit of successful cannulization of the umbilical vein is 24 hours, but sometimes this avenue can be utilised up to 48 hours.

If cannulization of the umbilical vein proves ineffective, the saphenous vein in the middle third of the thigh (*see* p. 22) should be utilised.

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CHAPTER III

THE ESTABLISHMENT AND MAINTENANCE OF FLUID AND ELECTROLYTIC BALANCE, WITH SPECIAL REFERENCE TO VENOCLYSIS

To overload the circulation is a grievous fault and grievously does the patient pay for it

The administration of plasma and of dextran is considered in the chapter on Shock pages 74, 70 while blood transfusion is set out in Chapter V

NORMAL INTAKE AND OUTPUT OF WATER

The Intake is derived from two sources (*a*) exogenous, and (*b*) endogenous.

Exogenous water is either drunk or ingested in solid food. The quantities vary within wide limits, but averages 2–3 litres per 24 hours, of which about one-third is contained in solid food ingested.

Endogenous water is released during the oxidation of ingested food and the amount is less than 500 ml. per 24 hours. During starvation this amount is supplemented by water released from the breakdown of body tissues.

The Output.—Water is lost from the body by four routes —

1 *By the Lungs.*—About 400 ml of water is lost in expired air each 24 hours. In a dry atmosphere and when the respiratory rate is increased, the loss is correspondingly greater

2. *By the Skin*—When the body becomes overheated there is visible perspiration, but throughout life invisible perspiration is always proceeding The cutaneous fluid loss varies within wide limits in accordance with the atmospheric temperature and humidity muscular activity and body temperature In a temperate climate the average loss is between 600 and 1000 ml. per 24 hours.

3. *Fæces*—Between 60 and 150 ml. of water are lost by this route daily In diarrhœa this amount rises by leaps and bounds.

4 *Urine.*—The loss by the first three routes is inevitable. The daily volume of urine is under the control of the body's water regulating mechanism,[1] and excess of water left in the body after the requirements of the first three routes have been met is excreted by the kidneys. It is generally agreed that the optimum urinary output should be 1500 ml. per 24 hours. This allows a margin for the elimination of an increased amount of nitrogen and electrolytes, if such be present in the blood. Provided the kidneys are functioning normally the specific gravity bears a direct relationship to the volume of the urine excreted (*Fig* 63).

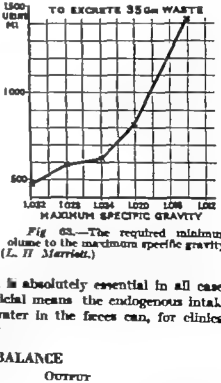

Fig 63.—The required minimum volume to the maximum specific gravity (*L. H Marriott.*)

For compiling an intake and output chart, which is absolutely essential in all cases where fluid balance is restored and maintained by artificial means the endogenous intake and (unless the patient has diarrhœa) the output of water in the fæces can, for clinical purposes, be disregarded without transgressing accuracy

NORMAL DAILY FLUID BALANCE

Intake		Output	
By mouth	3000 ml.	Insensible loss	1500 ml.
		Urine	1500 ml.
Total	3000 ml.	Total	3000 ml.

(*Le Quesne*)

[1] The secretion of the posterior lobe of the pituitary gland is the guardian of the osmotic pressure of the body fluids, a function that it performs by varying the water excreted. (A. G A. Lewis et al.)

The water requirements of infants and children are relatively greater than those of an adult because of (*a*) the larger surface area per unit of body weight (*b*) the greater metabolic activity due to growth (*c*) the comparatively poor concentrating ability of the immature kidneys.

AVERAGE DAILY WATER REQUIREMENTS

Adults	3000 ml.
6–12 years	2000 ml.
3–6 years	1500 ml.
1½–3 years	1000 ml.
Up to six months	500 ml.

NORMAL INTAKE AND OUTPUT OF ELECTROLYTES

Unfortunately the daily requirements of electrolytes cannot be calculated with the same facility as those of water

Sodium.—In temperate climates the average daily intake of an adult is probably 5–6 G (80–100 mEq.) About 4·5–5·5 G is lost in the urine, and less than 60 mg (10 mEq.) in formed fæces. The loss in perspiration is usually negligible however prolonged profuse sweating results in a considerable loss of sodium—as much as 2 G per hour (Nash) The coincident loss of water is relatively greater since sweat is hypotonic, but if water alone is given to counterbalance the fluid loss, serious sodium depletion can occur from excessive sweating There is no electrolytic loss whatsoever in expired air

Potassium.—A healthy adult consumes daily 3–4 G (78–94 mEq.) of potassium in food, and *nearly a like amount is excreted in the urine, with very small quantities in fæces* and sweat.

Flame Photometry—In large hospitals with full laboratory facilities, flame photometry has made possible rapid estimation of plasma sodium and potassium, so that day to-day or even more frequent, determinations can be made. For electrolytic determinations blood should be collected in a tube containing two drops of heparin solution (1000 units per ml.), immediately covered with liquid paraffin, and mixed the plasma should be separated as quickly as possible and kept under oil until the determinations are made.

Normal Values for Plasma

Na	137–147 mEq./L.	=	315–338 mg./100 ml.
K	4·0–5·3 mEq./L.	=	16–22 mg./100 ml.
Cl	93–105 mEq./L.	=	550–620 mg./100 ml. (NaCl)
HCO_3	25–30 mEq./L.	=	55–70 vol. CO_2/100 vol.

DEHYDRATION

Clinical manifestations of dehydration appear when there is fluid depletion corresponding to 6 per cent of the body weight. In most cases encountered in surgical practice dehydration involves a depletion of electrolytes, mainly if not entirely sodium chloride as well as water and most of the symptoms of dehydration are due to the loss of sodium

In established cases the eyes are sunken and the face is drawn. In infants the anterior fontanelle is depressed The tongue is coated and dry in advanced cases it is brown in colour Unlike the dehydration produced by loss of water only in water + salt depletion thirst is not particularly in evidence The skin is dry and often wrinkled, making the patient look older than his years. The subcutaneous tissue feels lax If the skin of a considerably dehydrated person is picked up between the finger and thumb and then released, instead of it springing back with normal elasticity a ridge is formed that subsides slowly *The peripheral veins are contracted and contain dark blood. The blood-pressure is likely to* be below normal. The urine is scanty dark in colour of a high specific gravity and contains little or no chloride.

Presuming that the erythrocyte count before the dehydration commenced was normal the hæmatocrit reading provides an index of the degree of hæmoconcentration. On the other hand, hæmoconcentration can be masked by pre-existing anæmia.

The Hæmatocrit is a specially graduated tube which is filled with a small quantity of freshly-drawn blood, to which has been added a little anticoagulant such as powdered

potassium oxalate The tube is centrifuged for 20 minutes and the volume occupied by the packed blood-cells is thus obtained Any increase of the volume of packed cells over 45 per cent in an adult male indicates a corresponding degree of dehydration (*see Fig* 122, p. 84)

PREPARATION OF SOLUTIONS FOR PARENTERAL ADMINISTRATION

The sterility of a solution for parenteral and particularly for intravenous, use must of course be assured. Furthermore the solution must be free from dead bacteria and other particulate matter as also must be the delivery tube Solutions prepared in the hospital pharmacy are from long personal experience never completely reliable all may go well for months at a time then there is an outbreak of untoward reactions attributable entirely to some fault in the preparation of the solution or the cleansing of the apparatus before it is sterilised. Pyrogens are the commonest cause of reactions they have been proved to be due to a specific bacterium isolated from distilled water Particulate matter which is another cause of reactions, can only be avoided by meticulous cleansing of the delivery tube before it is autoclaved, and lacquering the bungs of containers to prevent particles of the bung from entering the container For these reasons proprietary solutions manufactured on a large scale with facilities for the prevention of contamination that cannot be emulated by a hospital pharmacy are now used almost universally

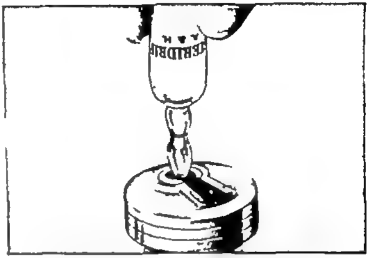

Fig 64 —Use of Sterivac with the Steridrip. The bottle is opened by removing the metal tag on TOP of the cap and pulling out the rubber disk plug thus revealed; the Steridrip is then pushed firmly into the ringed hole in the bung until a positive fit is obtained.

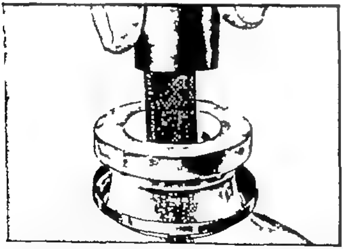

Fig. 65.—Use of Sterivac with M.R.C. internal-filter type fitment. The bottle is opened by tearing off the sealing band at the SIDE of the cap. This allows the whole cap and bung, complete with inlet tube to be removed. The M.R.C. fitment is then pushed home into the neck of the Sterivac.

Ready for Use Infusion Sets.—The inestimable value of solutions in flasks sealed by their manufacturers is their unquestionable sterility and freedom from dead bacteria.

The Sterivac[1] is obtainable in flasks of 1 litre or ½-litre capacity It can be used (*a*) with a Steridrip (*Fig* 64), (*b*) with the new M.R.C.[2] piercing needle or (*c*) by removing the bung and inserting the filter bung of a blood transfusion apparatus (*Fig* 65) When the attached tubing has been filled with the solution and all air bubbles have been removed, the infusion is commenced.

To change a nearly empty Sterivac for a full one a hæmostat is applied to the tubing and, according to the method being used, (*a*) the Steridrip is removed and inserted into a fresh flask, or (*b*) the piercing needle is removed and inserted

[1] Sterivac (Allen & Hanburys Ltd., Bethnal Green, London, E.2).
[2] M.R.C. (Medical Research Council).

into a fresh flask, or (c) the filter bung is removed and after withdrawing the bung of the full flask, the filter bung is inserted therein. The full flask is then hung on the stand and the hæmostat is removed.

The Vacoliter[1] is extremely simple to assemble and change (*Figs* 66–68)

Other manufactured products include Crookes Complete Unit.[2]

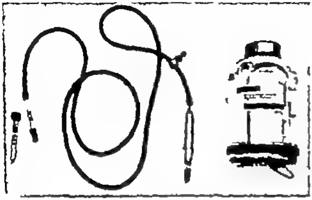

Fig 66.—The Vacoliter apparatus. This apparatus is made in the U.S.A. and Canada. It is not now *obtained readily in Britain, but is used extensively* elsewhere.

Fig 67.—Inserting the interceptor with the tubing attached

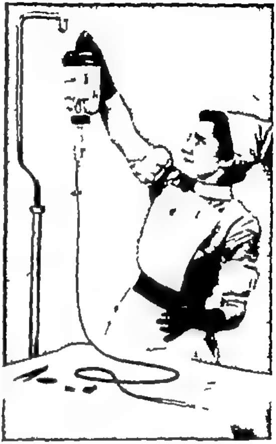

Fig 68.—Suspending the Vacoliter The apparatus is now ready for use

ELECTROLYTIC SOLUTIONS FOR INTRAVENOUS ADMINISTRATION

Normal saline solution is not now recommended for routine use in the *maintenance* of fluid balance for the following reason One litre of normal saline solution contains 8·5 G of salt. A normal adult requires 5 to 8 G of NaCl daily In health an excessive intake of sodium chloride is excreted readily but an ill patient should never be assumed to possess this power of elimination. To carry out fully their function of salt excretion, kidneys, especially aged and nephritic kidneys, require a rich supply of well-oxygenated blood under adequate pressure The very young are also unable to eliminate readily an excess of NaCl in the blood.

Another extremely important consideration is that patients suffering from *hypo*proteinæmia, i.e. those who for various reasons, have been unable to absorb a sufficient amount of protein for several days, are particularly prone to develop *hyper*chloræmia (*see* p. 34) if the administration of normal saline is continued after their NaCl requirements have been met For these reasons, in most instances a solution containing less salt than normal saline is indicated.

1 Dextrose 4·3 per cent with Saline 0·18 per cent (one-fifth normal saline).—This solution which is isotonic, may be regarded as the standard solution to employ It is referred to throughout this book as dextrose-saline solution. When the solution is

[1] Vacoliter (The Baxter Laboratories Inc., Morton Grove Illinois, U.S.A.).
Complete Unit (Crookes Laboratories Ltd., Park Royal, London, N.W 10).

continued for more than 24 hours it is essential to be absolutely certain that the patient is receiving sufficient sodium chloride; consequently the urine must be tested each day for the presence of chlorides. Fantus's test is performed easily and is accurate enough for clinical purposes.

The Fantus Test.—

Requirements: A 2·9 per cent solution of silver nitrate; a 20 per cent solution of potassium chromate; a glass dropper.

Method: Using the glass dropper, place 10 drops of urine in a test tube. Add 1 drop of the 20 per cent solution of potassium chromate. Rinse the glass dropper with distilled water and fill it with 2·9 per cent solution of silver nitrate. Add the silver nitrate solution to the urine drop by drop and shake the test tube after the addition of each drop. The end point is a colour change from yellow to brown. If the end point colour change occurs with the first drop, chlorides should be regarded as "absent".

Interpretation: The approximate sodium chloride content of the urine is given in grammes per litre by the number of drops necessary to bring about the colour change. The normal chloride content of the urine is 1–3 G. per litre.

Note. Preferably the test should be carried out on a 24-hour specimen of urine.

As long as chlorides are present in the urine there is no serious deficiency of that substance in the body, but the reverse is not true. Patients with renal failure fail to excrete chlorides (Sir Lionel Whitby).

2. **Normal (0·9 per cent) Saline Solution** is needed in the following conditions only: when there has been considerable vomiting or a large quantity of fluid has been removed by gastric aspiration. Excessive sweating is also liable to result in a state of hypochloræmia in health, a leading example is miner's cramp (the "bends") which arises after drinking enough plain water to satisfy thirst produced by profuse sweating. Perhaps the most potent cause of preventable hypochloræmia in surgical practice is produced by allowing a patient who is undergoing gastric aspiration to drink freely, the ingested fluid being aspirated promptly; this certainly washes out the stomach, but it also stimulates the secretion of HCl, large quantities (5 G. in each litre) of which are removed in the aspirate. This rather common practice should cease. When it is necessary to rest the alimentary canal it is best to limit the amount of fluid the patient is allowed to drink to 1 oz. (30 ml.) of water an hour. Even this is unnecessary: washing out the mouth with ice-cold water is effective in slaking thirst.

When the Fantus test shows a depletion of sodium chloride in the urine, usually 2 pints (1·14 l.) of normal saline solution is sufficient to replenish the lack for 24 hours.

Dextrose-saline and normal saline solutions meet all requirements in about 97 per cent of cases. The technique of their administration will be described first, and solutions that are indicated in comparatively rare circumstances will be considered afterwards.

THE PRACTICE OF ELECTROLYTIC FLUID THERAPY

Continuous parenteral fluid therapy, used intelligently, is of inestimable value in the treatment of many urgent surgical conditions. The contra-indications to its use are few; notwithstanding, they are most definite and should ever be before the surgeon and his whole team of co-workers.

Contra-indications.—

1. *The Failing Heart*.—A history of dyspnœa on exertion, uncompensated valvular disease, or any possibility of cardiac weakness should call for hesitation in increasing the bulk of circulating fluid.

2. *Pulmonary Congestion*.—In all conditions where there are signs of œdema or consolidation of the bases of the lungs the method should be absolutely forbidden.

3. *Hypertension*.—If the blood pressure is high, it is obviously courting danger to burden the circulation still further.

4. *Nephritis*.—In all its stages nephritis is a grave contra-indication.

Replacement and Maintenance Dosage.—When a patient is admitted in a dehydrated condition it is of course impossible to measure the loss of fluid and electrolytes he has sustained, but a detailed history of the nature and quantity of the fluid lost (usually, in surgical practice, by vomiting), and particularly the appearance of the patient, are the means by which the amount of electrolytic solution he should receive is estimated. The hæmatocrit reading may be a help in this direction. In most instances the necessary

fluid *replacement* should be undertaken by giving normal saline solution intravenously. When the bulk of the loss has been made up in this way, the *maintenance* of fluid balance is effected with dextrose-saline. In cases of extreme dehydration, where peripheral circulatory impairment is in evidence, it is advisable to commence by supplementing the volume of circulating fluid by dextran or a plasma infusion, and to follow this by substituting normal saline solution. When the fluid loss is considered to be rectified and fluid by mouth is contra-indicated, it is again advisable to supply the maintenance fluid requirements in the form of dextrose-saline solution.

In small infants the loss of weight[1] that has occurred can usually be calculated, and on a basis of 1 pint (568 ml.) of water weighing 1¼ lb. (570 G.) the loss can be used to estimate the amount of *replacement* fluid that can be administered comparatively quickly.

Rate of Flow.—The average rate of flow for an adult in need of fluid should be 50 drops a minute, i.e., ¼ pint (140 ml.) per hour or 6 pints (3·4 L.)[2] in the 24 hours. In severely dehydrated patients, for the first hour the rate can be accelerated to 100 drops a minute, after which the rate should be decreased by half. If in doubt as to how much fluid the patient should receive, the flow should be cut down to 30 drops a *minute*, i.e., approximately 3½ pints (2 l.) in the 24 hours—a dose that, at any rate, is unlikely to do harm. Once the initial deficit has been replaced, the maintenance dose for the succeeding 24 hours is calculated as described on p. 26 and in no circumstances whatsoever must this amount, stated in writing, be exceeded. In this connexion the following table will prove valuable :—

Drops per minute	*Volume in the 24 hours*	
	Litres	*Pints*
10	0·675	1
20	1·35	2[illegible]
30	2	3½
40	2·7	5
50	3·4	6
60	4	7
70	4·7	8[illegible]
80	5·5	9[illegible]
90	6	10[illegible]
100	6·7	12

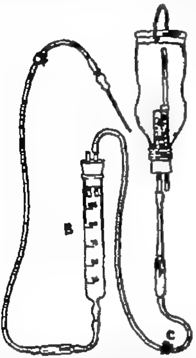

Fig. 60.—The interposition of a small, closely calibrated reservoir in the infusion set permits slow and accurate drip infusion. A burette (B) is filled to one of the marks, and the clamp (C) is closed. If the infant is to receive more than 125 ml. the burette is refilled when the level has fallen to the 25-ml. mark.

In a number of instances the amount of fluid that the patient is to receive *hourly* (which must be stated in writing) is small. A leading example is during infancy, when as little as 20–30 ml. per hour is required. In premature infants this must be reduced to 10–20 ml. per hour. The interposition of a smaller, more closely calibrated reservoir (*Fig.* 60), which is filled as required from the standard reservoir, is then invaluable, and is a safeguard against overloading the circulation.

Charting Fluid Intake and Output.—When fluid is administered intravenously, intramuscularly, subcutaneously, per rectum, or via a gastric aspiration tube it is absolutely essential that the amount of fluid the patient receives should be recorded. It is equally important that all urine passed during each 24 hours should be measured, recorded, and saved. To this figure is added fluid recovered by gastro-intestinal aspiration, plus that lost from a fæcal, urinary, biliary, or pancreatic fistula. To this total is added 1500 ml. for insensible fluid loss from the lungs and skin. If the patient has been sweating, the last figure is increased. It is the nursing vigilance in recording throughout the 24 hours, the intake of fluid by the patient and the output of urine that is so vital, and the accuracy of these records reach their zenith of importance during the administration of fluid intravenously. If a special printed form for entering the data is lacking, a chart can be improvised

[1] Daily weighing of infants is extremely useful in assessing daily fluid requirements.
[2] Pints × 0·5682 = litres.

easily. The sheet should be balanced at the same time each day, say at 10 a.m., and from this the patient's fluid requirements for the ensuing 24 hours is calculated.

The Prevention of Overhydration.—Over and over again continuous intravenous therapy proves a veritable breath of life; nevertheless bitter experience has taught me that, when fluid is allowed to gravitate into a vein the patient is absolutely at the mercy of those in attendance upon him. The stomach and the large bowel eject excessive or unsuitable fluid; muscle or subcutaneous tissue that is becoming overloaded commences to swell and pain is experienced; but if excessive fluid is gravitated into a vein neither the patient nor his tissues obviously rebel until he is literally drowning. So it comes about that unless it can be assured that continuous intravenous therapy will be adjusted to the patient's varying requirements with skill and unremitting vigilance it is best to conclude the infusion at the expiration of 24 hours, and, after an interval, if it is unsafe to allow the necessary amount of fluid by mouth, a stated quantity of fluid is given by one of the less dangerous routes described in Chapter IV.

The Administration.—The actual administration is largely in the hands of the nursing staff. It is of paramount importance to be sure that the nurse appreciates her simple vital responsibilities connected with the administration of fluid intravenously.

Nursing Instructions.—

1. On no account allow the reservoir to become completely empty. When the fluid is running low, either make arrangements for changing the nearly empty container for a full one or stop the infusion altogether. The application of a Spencer Wells forceps to the tubing is imperative when the fluid in the reservoir is within 2 in. (5 cm.) of emptying.
2. Watch the limb in the region of the needle for œdema. Apply Spencer Wells forceps to the tubing if you see swelling of the tissues or if the patient complains of pain in the limb.
3. Veins are easily obstructed. There should be no bandage over the line of the vein.
4. The number of drops per minute that the patient is receiving should be timed and recorded at frequent intervals.
5. Should the drip chamber become overfull and the fall of drops is obscured, report the matter.
6. If the flow stops: (*a*) Do not pinch the tubing. (*b*) See if the tubing is kinked. (*c*) If the flow is not restarted by some simple adjustment of the limb or the tubing report the matter at once.
7. Watch for and report immediately: (*a*) Rigors. (*b*) Redness along the vein. (*c*) Œdema of the feet, face, or arms, and (*d*) Any sign of respiratory distress.
8. Measure, record, and save all urine passed by the patient. If the output becomes scanty report the matter. Also report if the specific gravity becomes low (1010 or below).

VITAMIN REQUIREMENTS FOR A PATIENT MAINTAINED ENTIRELY ON INTRAVENOUS FLUIDS

Unless total intravenous alimentation is required for more than a week there is no need to supply fat-soluble vitamins, of which there will be an adequate supply stored in the body. The requirements of the vitamin B complex vary considerably, more being required if there is a deficiency of dextrose metabolism. Antibiotics produce vitamin deficiency, notably of the B complex. Therefore it is best to err on the side of safety and assume that a liberal amount of B vitamins will be required. Vitamin C should be given in large doses to ensure saturation.

Twin ampoules of parenterovite intravenous (high potency)[1] are recommended daily. They should be mixed before being injected into the tubing of the intravenous apparatus. Together these ampoules contain:—

Aneurine hydrochloride	250 mg.
Nicotinamide	160 mg.
Riboflavine	4 mg.
Pyridoxine	50 mg.
Calcium pantothenate	5 mg.
Dextrose	1 G.
Ascorbic acid	500 mg.

[1] Parenterovite intravenous (Vitamins Ltd., Upper Mall, London, W.6).

TOTAL INTRAVENOUS ALIMENTATION

For an adult 4 litres of fluid are given each 24 hours, consisting of 3 litres of 10 per cent dextrose and 1 litre of protein hydrolysate, to which are added 10 G. of NaCl and 3 G. of KCl, together with the contents of twin ampoules of parenterovite intravenous (high potency) (*see* p. 31). The chloride and vitamin solution is prepared by making a sterile solution of 10 G. of NaCl, 3 G. of KCl and the contents of the twin ampoules of parenterovite dissolved in 120 ml. of distilled water. Half this solution (60 ml.) is injected into a 500-ml. bottle of 10 per cent dextrose, which is administered during the morning, and the other half similarly is injected into the bottle that is given during the afternoon. This daily 4 litres of intravenous fluid supplies 100 G. of protein and 300 G. of carbohydrates, or about 1600 calories. At least one and, with no possible harm, two half-litres of the dextrose solution can be fortified with alcohol, as described below, thereby increasing the daily intake of calories.

These solutions, especially those containing 10 per cent dextrose, suffer from the disadvantage of causing a high incidence of thrombosis in the vein employed. This is minimized by introducing polythene tubing into the vein for some distance.

Total intravenous alimentation is contra-indicated in patients with depressed liver function, those with imperfect kidneys (as shown by a raised blood-urea), and those with cardiac disorders.

SOLUTIONS REQUIRED FOR OCCASIONAL USE

1. **Dextrose 5 per cent Solution** is seldom required, and it should not be given unless there is a special indication, for when administered intravenously it is liable to cause thrombosis of the vein employed. However, should the salt requirements of a patient needing much fluid be satisfied on any particular day by dextrose-saline, rather than risk hydræmia, 5 per cent dextrose solution can be substituted for the remainder of the 24 hours.

2. **Darrow's Solution** was introduced for the treatment of infantile diarrhœa and vomiting. It contains sufficient potassium to combat hypopotassæmia (hypokalæmia), and in surgical practice it is a safe and convenient method of supplying this salt. After four days of parenteral fluid therapy, a litre can be given as a prophylactic measure against hypopotassæmia. In cases of established hypopotassæmia, one litre can be given during 24 hours until the deficiency is remedied. The composition of the solution is as follows:—

Potassium chloride	2·7 G.
Sodium chloride	4·0 G.
Molar sodium lactate	50 ml.
Water for injection to	1000 ml.

3. **Protein Hydrolysate.**[1, 2, 3]—A solution containing amino-acids is available. The only indication for the use of this parenteral fluid is in cases of hypoproteinæmia (e.g., following prolonged gastro-intestinal aspiration, profuse fæcal fistula). Usually the amount given should not exceed 1 pint (568 ml.) in 24 hours.

4. **Intravenous 5 per cent Alcohol.**—The Calorie value of dextrose is 4 Calories per gramme, so the amount that can be administered intravenously in a 5 per cent solution provides insufficient Calories for the maintenance of nutrition; this can be supplemented by alcohol.

Ethyl alcohol given intravenously has a wide margin of safety. A normal adult can metabolize approximately 10 ml. of pure alcohol per hour—a rate of administration higher than this is liable to produce intoxication. A 5 per cent solution of alcohol contains 10 ml. of pure alcohol in every 200 ml. of fluid, an amount that is completely metabolized in one hour by the average adult. One ml. of alcohol yields 5·6 Calories. Alcohol, when administered for nutritional purposes, is usually given in conjunction with dextrose-saline or an amino-acid solution. To prepare a 5 per cent solution of alcohol, inject into a litre flask of dextrose-saline solution 53 ml. of 95 per cent alcohol or 58 ml. of 90 per cent alcohol. Sterile solutions of 90 per cent and 95 per cent of alcohol in ampoules[4] are available for this

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[1] Aminosol (Abbott Laboratories L[illegible] ...enford, Middlesex).
[2] Amigen (Mead, Johnson & Co., ... Indiana, U.S.A.).
[3] Travamin (Baxter Laboratories, ...n Grove, Illinois, U.S.A.).
[4] Supplied by Allen & Hanburys, ... E.2.

purpose. One litre of 5 per cent alcohol in dextrose-saline solution yields 480 Calories (280 being derived from the alcohol and 200 from the dextrose). Both alcohol and dextrose increase the body's needs for thiamin, riboflavine and nicotinic acid and these vitamins should be added to the alcohol-dextrose-saline solution.

Intravenous alcohol is also a sedative and an analgesic. Alcohol because of its peripheral vasodilator effect should not be used in the presence of shock or in patients with demonstrable liver damage. Seeing that the effect of alcohol is unpredictable a patient receiving intravenous alcohol should never be left alone for any length of time—a special nurse is always required.

The incidence of chemical thrombophlebitis is not increased by the addition of alcohol to dextrose-saline but the discomfort in the region of the affected vein is greater. This is minimized by passing polythene tubing up into one of the larger veins, when possible. An injection of 5 ml. of 1 per cent procaine relieves the discomfort.

5. **Fat Emulsions** are as yet not available on a commercial scale but doubtless in the future they will play a great part in providing an unrivalled number of calories intravenously. One litre of a specially prepared 10 per cent emulsion of coconut oil has a value of 1200 Calories. There are no especial dangers in the administration of this emulsion. Reactions, if they occur, are mild; pyrexia of 3° F. (1.7° C.) is the most common; nausea, and occasionally vomiting, with giddiness occur less frequently. Thrombophlebitis is not engendered by this emulsion, which will drip through the usual venoclysis set. If necessary a litre can be given in 2 hours. Fat emulsions have also been given subcutaneously with hyaluronidase.

THE HAZARDS OF FLUID THERAPY

Pyrogenic Reactions are uncommon when reliable proprietary solutions are employed. If a rigor occurs, the infusion must be discontinued immediately. When rigors do not cease after a few minutes, an intravenous injection of $\frac{1}{6}$ gr. (11 mg.) of morphine is almost always effective.

Water Intoxication is relatively uncommon. The knowledge that sodium retention occurs normally during the early post-operative period has led to a rather widespread use of isotonic 5 per cent dextrose solution with the result that not a few patients have become waterlogged. Water intoxication has also followed the rectal administration of tap water. This complication occurs more often after the age of 50 and when renal function is impaired; it has also been encountered in the neonatal period. Water intoxication has occurred after the administration, in an adult, of as little as 3 litres in 24 hours, but usually considerably greater quantities than this are necessary to produce the condition. The rate at which the fluid is administered seems to be a critical factor. In most cases it had been given at a fast rate.

Diagnosis.—Nearly all reported cases have arisen within 48 hours of operation and most of them within 36 hours. The first symptoms are rapid and stertorous respirations, twitching of the limbs and mental confusion follow. However, the characteristic feature of water intoxication is convulsions of the *grand mal* type followed by unconsciousness or coma which lasts for several hours or days. Convulsions occurred in 16 out of 17 cases reported by Zimmermann and Wangensteen. Œdema of the limbs is uncommon, but puffiness of the eyelids is often present. At first there is diuresis and a large volume of dilute urine, low or deficient in chlorides, is passed. This is followed by oliguria or anuria and sweating ceases.

Treatment.—The infusion of salt free fluid must cease forthwith. In severe cases the intravenous administration of hypertonic (2 per cent) saline solution, if started early enough, often brings about a resumption of renal activity. Not more than 200–300 ml. should be given, and it must be administered slowly and stopped as soon as the symptoms are relieved or a satisfactory amount of urine containing chlorides is recovered, otherwise cardiac arrest or circulatory overloading is liable to supervene.

Sodium Depletion.—Unlike the foregoing, the symptoms seldom arise until an infusion lacking in the necessary amount of sodium has been in progress for more than 48 hours. Provided the urinary excretion is excellent, the register of a fall in urinary chlorides is indicative that the patient is in need of NaCl. However, the best evidence of sodium deficiency is a plasma-sodium estimation.

Diagnosis.—The early symptoms are headache and giddiness. The salt deficiency causes pylorospasm, and the resulting vomiting adds to the salt deficiency (Marriott) Peripheral circulatory impairment follows.

Treatment.—Sodium should be replaced by giving 1–2 pints (say 0·5–1 litre) of normal saline intravenously but the best immediate treatment in severe cases is a blood transfusion (Moore and Ball)

Sodium Excess.—Warnings have been sounded already concerning the dangers of giving too much parenteral fluid, especially normal saline particularly in the early post operative period when some degree of sodium retention is to be expected. The danger of sodium chloride retention is considerably increased if there is coincident hypoproteinæmia. Sodium excess and hydræmia go hand in hand and in response to the law of osmosis, permeation of fluid occurs from the capillaries into the extracellular tissue spaces. Even a subclinical degree of sodium excess is harmful for it results in œdema of intestinal and other suture lines and is, for instance a cause of non functioning of an end to-end intestinal anastomosis. A plasma-sodium level of above 147 mEq per litre (338 mg per 100 ml) is proof that the patient has received too much sodium

Diagnosis.—The first visible sign is often puffiness of the face If the ankles and sacral region are examined, pitting œdema may be found if pitting œdema is present at least 1 gallon (4 5 l) has accumulated in the tissue spaces (Marriott) Signs of over hydration in infancy (infants are very susceptible) are increased tension in the anterior fontanelle, increase in weight increase in the number of urinations, and œdema

Treatment.—In all cases of sodium excess the infusion should be stopped In extreme instances the ever present danger is pulmonary œdema, which often comes on suddenly If this occurs, having stopped the infusion —

1 Place the patient in Trendelenburg's position and institute postural drainage of the lungs (*Fig* 70).

2. Give 0·5 mg of digoxin intravenously

3. Having emptied the lungs prop the patient in a comfortable sitting posture and administer 100 per cent oxygen.

4 Order coramine 2 ml four hourly

5 Repeat the postural drainage and digoxin at 2–4-hourly intervals, if necessary

6 If the urinary output is unsatisfactory after consultation with a physician, consider the advisability of injecting 2 ml. of mersalyl intravenously

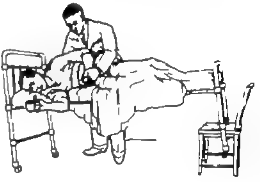

Fig 70.—Postural drainage

Hypopotassæmia (syn. Hypokalæmia).—Potassium is chiefly an intracellular ion. As the kidneys are unable to conserve this element, excretion continues in all circumstances save in anuria or severe oliguria. When, over a period of days, the intake of potassium is zero or negligible and particularly when this is accompanied by increased potassium loss from vomiting or gastro-intestinal aspiration some degree of potassium deficiency should be strongly suspected When possible a plasma potassium estimation is valuable in confirming the deficit, but it must be realized that in severe dehydration intracellular potassium deficiency can occur with a normal plasma level. When it is due to vomiting gastro-intestinal aspiration or a high small intestinal leak hypopotassæmia is usually accompanied by severe alkalosis, and by acidosis when it is due to diarrhœa or to a low intestinal fistula.

Diagnosis.—At first the patient lies listlessly in bed. This is soon followed by intense drowsiness, the patient being aroused with difficulty and in established cases, when awakened he is not fully orientated. All he appears to desire is to be left in tranquillity to sleep Muscular hypotonia is an outstanding clinical feature The patient moves his limbs but little and in some cases there is actual paralysis of the legs. Reflexes are lost and incontinence of urine is common. Abdominal distension amounting to paralytic ileus is a constant accompaniment, and in all cases of paralytic ileus the plasma potassium level should be investigated Respiratory difficulty due to weakness of the intercostal muscles and the diaphragm occurs frequently and is characterized by rapid, shallow gasping respirations ; these are conducive to post-operative pulmonary complications The diastolic blood pressure is low but there is usually a bounding pulse and a presystolic

murmur. Often the diagnosis can be confirmed by electrocardiography, which shows a prolonged QT interval and a lowering or inversion of the T wave, but these changes are not always present, even in severe deficiency.

Treatment.—It should be especially noted at this juncture that administration of Na *is liable to aggravate the K loss, and Na should be withheld until the K deficit has been* corrected. When possible, potassium deficiency should be remedied by giving potassium by mouth. For this purpose potassium chloride 30 gr. (2 G.) six hourly can be given in fruit drinks. Alternatively, potassium citrate 40 gr. (3 G.) is substituted. When the patient is comatose, or has difficulty in swallowing, the potassium is given by a transnasal intragastric tube. If ingestion is inadvisable, the intravenous administration of potassium, which is not without danger, is unavoidable. Because of the risk of raising the extracellular potassium concentration to a dangerous level *and thus causing cardiac arrest, it is essential* to ensure, whenever possible, that there is an adequate excretion of urine (at least 500 ml. per 24 hours). To this end it is advised to gravitate intravenously 500 ml. of 5 per cent dextrose solution before administering the chosen solution of potassium, and to verify by catheterization if necessary, that the kidneys[1] are functioning adequately. It is also essential to have an hourly pulse rate recorded during the administration of potassium, and if the pulse becomes slow, to substitute 5 per cent dextrose solution for the potassium infusion. Not more than 3 G. of potassium should be given *in 24 hours, and it should* only be repeated after consultation with a physician. If as is usually the case, the patient is suffering from concomitant alkalosis, potassium chloride should be employed. The 3 G. of potassium chloride is dissolved in 10 ml. of sterile water and added to 1 litre of dextrose saline solution. This is gravitated into the vein at the rate of 20 drops per minute. When the patient is suffering from concomitant acidosis a litre of Darrow's solution, which contains sodium lactate, should be substituted for the above solution, and given in exactly the same manner.

Hypoproteinæmia.—Except in the presence of a profuse duodenal or jejunal fistula, hypoproteinæmia is most unlikely to develop within five days of total parenteral sustenance with crystalloid solutions. As a rule the patient has a lean and hungry look. Œdema is likely to develop, especially in the area of the wound, leading to delayed healing. Œdema of the pyloric mucous membrane, causing delay in gastric emptying, is frequently present in this condition. Œdema does not appear until the plasma proteins are grossly depleted and the body reserves of *mobile proteins are exhausted. Once present,* hypoproteinæmia takes a long time to remedy, even when the patient can take nourishment by mouth. Milk fortified with powdered skimmed milk is an excellent source of protein. In other circumstances protein hydrolysates must be given intravenously or, if permissible and possible, by duodenal intubation. As an emergency measure the administration of 1 pint (568 ml.) of plasma will supply the patient with his immediate protein needs.

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[1] In a patient with poor renal function potassium should not be administered unless a [illegible] sium level exists, and then only with redoubled caution.

CHAPTER II

REPLENISHING THE CIRCULATING BODY FLUIDS *(continued)*: ALTERNATIVE METHODS

ALTHOUGH a certain latitude is permissible for personal preference the indications for the administration of fluid by the rectal subcutaneous, or intramuscular routes are comparatively few There was a time when many considered that the administration of fluid by one o these routes was comparatively foolproof and therefore they tended to resort to one or other of them when the patient was being treated in a small hospital a nursing home or in his own house where the same degree of supervision that could be expected in a larger institution was lacking However especially since the introduction of hyaluronidase as an adjuvant to the absorption of fluids administered subcutaneously or intramuscularly because one of the alternative routes to intravenous fluid therapy has been chosen it is inadmissible to relax the necessary constant vigil on fluid balance.

Hyaluronidase,[1] which causes diffusion and therefore acceleration of absorption of fluids injected or gravitated subcutaneously or intramuscularly is a mucolytic enzyme manu factured from bulls testes, and is issued as a sterile powder in ampoules of 1000 units. The powder is readily soluble in sterile water It is important that the syringe and hollow needle employed be free from antiseptics, since these inactivate the enzyme; for the same reason, the solution must be prepared freshly immediately before use. The dissolved hyaluronidase must be injected *before* the fluid to be infused and the most convenient method is to inject the enzyme through the rubber tubing of the infusion apparatus about 1 in. (2 5 cm.) above the needle as soon as the fluid has commenced to gravitate into the chosen site Usually 1000 units of hyaluronidase is sufficient to accelerate the absorption of 1000 ml. of fluid however should swelling at the site of the injection be observed, the dose of hyaluronidase can be repeated In this way approximately 100 ml of isotonic saline or dextrose-saline is absorbed every 20 minutes, and therefore volumes up to 2000 ml. can be administered in 8 hours without trauma or swelling of tissues at the site of injection, and without pain. By the aid of hyaluronidase 100 ml of dextrose-saline solution can be injected subcutaneously into the scapular region of an infant in 30 minutes without pain or leakage at the site of the puncture

Mode of Action—Hyaluronidase occurs naturally in the venom of certain poisonous snakes and insects as a product of some highly invasive bacteria, such as *Cl. perfringens* and in certain tissue extracts, notably of mammalian testes.

Tissue spaces are walled by connective tissue The chief constituent of the matrix of connective tissue that preserves its normal jelly like consistency is a cement or ground substance hyaluronic acid which is an acid polysaccharide of gigantic molecular size

As a result of interaction between hyaluronidase and hyaluronic acid almost instantly the latter is depolarized and liquefied to nearly the consistency of water After cessation of the infusion 24–48 hours are required for complete restitution of the ground substance referred to

Contra indications to the Use of Hyaluronidase—It is necessary to realize that hyaluronidase is completely ineffective if the patient is in a state of severe shock or is suffering from hypoproteinæmia or venostasis. It is also important to remember that with this enzyme it is dangerous to give dextrose solution without sodium chloride to patients with electrolytic deficiency In this circumstance diffusion of the already depleted sodium and potassium salts from the blood-stream into the infusion area may be sufficient to induce a shock like state

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[1] Hyalase (Benger Laboratories Ltd.); Rondase (Evans Medical Supplies Ltd.) Wydase (Wyeth Incorp., Philadelphia Pa.).

CONTINUOUS INTRAMUSCULAR INFUSION[1]

The advantage of this route is that in a hospital without a resident doctor an experienced Sister, following telephone instructions, can insert a needle into the muscles of the thigh and administer the stated quantity of fluid herself.

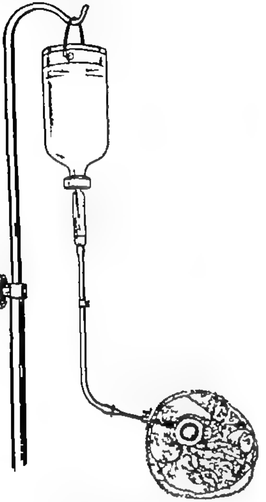

Fig. 71.—Continuous intramuscular administration of dextrose-saline solution into the lateral aspect of the middle third of the thigh.

The best site for the injection is the external side of the middle third of the thigh (*Fig.* 71). Billimoria and Dunlop's needle with its adjustable shield (*Fig.* 72) is an asset. The needle is inserted nearly

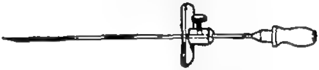

Fig. 72.—Billimoria and Dunlop's needle for intramuscular administration of fluid. (*Made by Messrs. Thackray.*)

down to the bone, when the adjustable shield is fixed by turning the screw, making further penetration impossible. It is a good practice to insert the needle through a piece of sterile gauze which comes to lie between the shield and the skin. Once the needle is in place satisfactorily it can be kept in position by adhesive plaster placed over the shield. A rate of about 40 drops a minute is suitable for most adults in need of fluid. When both thighs are used, a Y-shaped glass connexion is interposed in the tubing leading from the flask. Each tube leading from the Y-shaped connexion should possess an interceptor so that the flow to each thigh can be regulated.

SUBCUTANEOUS INFUSION (HYPODERMOCLYSIS)

A subcutaneous infusion administered correctly does not cause much discomfort, but even so the discomfort it occasions is one of its chief drawbacks. Should the infusion be given into an unsuitable site, or too rapidly, discomfort becomes pain. Pain and slow absorption, are good reasons for the relative unpopularity of this route. However, following the introduction of hyaluronidase some of the former popularity of subcutaneous infusion has been regained.

Without question the site of election for the infusion is an axilla. With a Y-shaped connexion, both axillæ can be utilized at the same time. After the elimination of air bubbles from the tubing and being assured that the fluid is flowing freely, the needle (No. 19 S.W.G.) attached to the tubing and the reservoir, which is supported about 3–4 ft. (90–120 cm.) above the patient, is introduced 1 in. (2.5 cm.) below the inferior border of the origin of the pectoralis major (*Fig.* 73) and

Fig. 73.—Site of election for introducing a hollow needle for subcutaneous infusion.

[1] Only dextrose-saline or saline solution should be given by this route.

directed towards the centre of the axilla. The advantages of this site over all others are that the subcutaneous tissue is loose and the lymphatic supply for absorption is plentiful. The anterolateral surface of the thighs and the lower abdominal wall are also sites that can be utilized. For an infant, the region of the scapula is suitable.

CONTINUOUS RECTAL INFUSION (PROCTOCLYSIS)

The administration of fluid via the rectum has the advantage of simplicity It requires but little apparatus, and neither asepsis nor isotonicity Its great disadvantage, if not danger is the uncertainty of the method not infrequently the fluid is expelled—too often by patients who need it most.

Avery Jones advises *dilute* saline solution for proctoclysis, viz. to 1 pint (658 ml.) of normal saline is added 4 pints (2 3 L) of tap water Dilute saline given per rectum avoids the absorption of an excessive quantity of sodium chloride, that results in hydræmia.

Via a catheter in the rectum, the fluid is given by the drip method according to the needs of the patient. The rate of administration should not be greater than 60 drops a minute This may be too much for some patients, and if fluid is returned the rate must be reduced. It should be noted that there is no point in administering dextrose per rectum for little, if any is absorbed.

GRAVITATING FLUID INTO THE STOMACH BY THE DRIP METHOD

When it is unnecessary to keep the alimentary tract at rest and the patient cannot or will not drink a sufficient quantity of fluid a simple and effective method of ensuring an adequate fluid intake is to gravitate the fluid into the stomach through an indwelling gastric (aspiration) tube. Two pertinent examples where the expedient proved admirable are illustrated in *Figs.* 74 and 75 Widely divergent cases where this method can be employed with advantage constantly occur in surgical practice. The receptacle is hung 1–2 ft (30–60 cm.) above the level of the top of the patient s head. Once an intranasal gastric tube is in place, fluid can be gravitated into the stomach at a given rate. There are occasions when, in order to ascertain if the fluid that has entered the stomach is passing onwards, the tube should be used, from time to time for aspiration. An important advantage of this method over the rectal route is that nourishment (e.g., dextrose) can be given, and is likely to be absorbed, from the commencement of the treatment

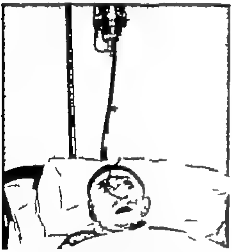

Fig. 74.—Pyelonephritis. Will not drink unless coaxed Adequate fluid intake maintained by intragastric drip feeding

Fig. 75.—Persistent hiccup following herniotomy lasting many days. Not severe enough to warrant exposure of the phrenic nerve The hiccup was kept under control and cured by intragastric drip feeding for five days.

Transnasal Polythene Tubing for Feeding.—The superiority of oral alimentation when permissible over the intravenous route is well recognized. Fine-calibre polythene is non irritant, and can be tolerated in the upper gastro-intestinal tract for long periods. Lovelace

recommends polythene tubing with an outside diameter of 2·4 mm. for this purpose. The tube is cut to the same length as a Ryle's tube and is passed down the nostril in the same way. It is much better to introduce the liquid nourishment into the stomach than into the duodenum or the jejunum but should it be necessary to pass the tube into the jejunum, e.g., past a fistula, a somewhat longer length of tubing is taken. To pass the tube into the upper jejunum, the distal 2 in. (5 cm.) of a finger of a rubber glove is cut off, and in it is placed 5–10 ml. of mercury. The mouth of the finger-cot is tied securely by one end of a long piece of silk. The bag containing the mercury is passed down the nostril in the same way as a Miller-Abbott tube. When a radiograph shows that the bag has entered the jejunum, the polythene tubing is threaded on the silk and passed onwards until its tip reaches the neck of the bag. The silk is then cut, and together with the bag in due course it is passed per rectum. Watery fluids can be gravitated through the tube by the drip method. To introduce fluid of a thicker formula through this fine tubing a syringe or a mechanical pump must be used.

By way of the tube up to 6000 Calories a day can be given, and it is possible to increase the patient's weight by as much as 1 lb. (450 G.) a day for three weeks.

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CHAPTER I

BLOOD TRANSFUSION

The ABO Groups are inherited They are determined by the presence or absence *in the erythrocytes* of two agglutinogens—A and B—which give rise to four groups—AB A, B, and O O being used to designate an absence of both agglutinogens.

There are also present or absent *in the plasma* two iso-agglutinins—anti A and anti B If A is absent from a person s red cells, anti A iso-agglutinin is found in the serum. Conversely if B is absent from a person s red cells, the serum contains anti B iso-agglutinin. Exceptions to this rule are very infrequent in adults.

The full constitution of each group is given in the following Table —

GROUPS (INTERNATIONAL NOMENCLATURE)	AGGLUTINOGENS IN RED CELLS	ISO-AGGLUTININS IN SERUM	DISTRIBUTIONS	
			Great Britain	*U.S.A*
AB	A and B	Neither	per cent 3	per cent 4
A	A	Anti B X	42	41
B	B	Anti A X	8	10
O	Neither	Anti-A X and Anti-B X	47	45

From this Table it will be seen that the plasma of group O blood contains both anti A and anti B iso-agglutinins. Therefore it cannot be emphasized too strongly that a group O donor should not necessarily be looked upon as a universal donor If the iso-agglutinins it contains be potent, group O can cause serious hæmolytic reactions (*see* p 62) if transfused into an AB A or B recipient. On the other hand in the more restricted field of military surgery where the recipients are exceptionally healthy young men up to the time of wounding, it has been made abundantly clear that group O blood *of low iso-agglutinin content, as determined in highly specialized laboratories* is remarkably safe Only group O Rh positive blood was shipped to the combat zone in Korea, and this blood was given without preliminary cross-matching to all casualties in need of transfusion irrespective of their blood group All blood dispatched had been tested previously by expert pathologists for the presence of high titre iso-agglutinins active against group A and B cells (*Fig* 76) Where agglutination occurred the blood was called high titre and bottles containing it were clearly labelled To be given to group O recipients only Where there was no agglutination of ABO red cells when submitted to this test, the blood was considered to be of low titre, and could be given to any wounded man. In 1952 over 60 000 transfusions were given in Korea, and during the period only 4 patients suffered post transfusion hæmoglobinuria. Each of the 4 had been given blood that was procured locally in Korea (Akeroyd and Crosby) Extraordinarily successful as this plan proved the fact that approximately 50 per cent of Rh negative recipients were bound to be sensitized by Rh-positive blood as will be explained in the section to follow immediately must not be lost sight of and this plan would be most unsafe in civil practice

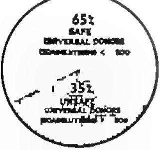

Fig 76.—The distribution of safe and unsafe universal donors. (*After Akeroyd and Crosby*)

The Rhesus Factor.—There are no inherited Rh agglutinins in the blood; they are acquired only by introducing erythrocytes containing Rh antigen into the circulation of a recipient whose blood lacks that particular Rh antigen, or during pregnancy of a Rh negative mother bearing a Rh positive fœtus. The common Rh antigen is D, and it occurs in the red corpuscles of 85 per cent of Europeans. When the red cells contain this antigen the blood is termed Rh positive (Rh +). Rh negative (Rh —) blood is that which lacks Rh antigen D, and about 15 per cent of Europeans are of this type.

Rh Sensitization and Its Dangers.—If transfused with Rh-positive blood, 50 per cent of Rh negative individuals will become immunized, the possible complications of which differ in some respects in the two sexes.

When a Rh-negative *man* receives a transfusion of Rh-positive blood, the first transfusion is nearly always symptomless. Further transfusions of Rh positive blood are likely to be followed by progressively alarming symptoms and signs—headache, jaundice and later hæmoglobinuria, oliguria, and anuria. In many instances transfusions must be repeated several times before agglutinins appear.

In the case of a Rh negative *woman* there are additional dangers —

1. If a Rh-negative woman is bearing, or has been delivered recently, of a Rh positive child, her plasma might be heavily charged with Rh antibody; consequently violent reactions are especially liable to develop during a transfusion of Rh-positive blood.

2. Any Rh-negative woman who has borne a Rh-positive child, or has aborted a Rh-positive fœtus and who has become sensitized, remains sensitized probably for life. Those who have had an infant affected with icterus neonatorum, a stillborn infant, or a macerated fœtus, should be regarded as highly sensitive to Rh-positive blood, unless the contrary is proved.

3. If transfused with Rh positive blood at any time from infancy to the menopause a Rh negative female may be rendered incapable of producing a Rh positive living child, and liable to dangerous hæmolytic reactions if at any future time a further transfusion of Rh-positive blood is given to her. Once Rh antibodies have appeared in the blood of a Rh negative female, they persist for a very long time, probably for life.

Thus it will be realized how important it is to ascertain the Rhesus factor in every woman who has to be transfused, and how desirable it is to do likewise in every man, especially if further transfusions are likely to be required. When urgency or lack of facilities do not permit Rhesus testing, Rh-negative blood must be employed in every case where a female is in urgent need of transfusion, and to men who are likely to need further transfusions.

Incompletely Rh positive Individuals.—In about 2 per cent of persons whose blood is Rh D negative, there is present one of several other Rh antigens. These partially Rh positive bloods, if transfused into a Rh-negative person, may provoke the production of specific agglutinins. Should the recipient so immunized be unfortunate enough to be transfused again with blood containing the particular antigen, a serious reaction is likely to occur.

BLOOD GROUPING, RHESUS TYPING, AND CROSS-MATCHING

Accurate blood grouping, Rhesus typing, and cross-matching by a pathologist with special training in this work are not only highly desirable, they are almost essential, for, whenever possible, the patient must be transfused with blood not only of his own group and Rh type, but blood that has been proved to be compatible in every respect. These tests require 2 to 2½ hours for their performance. In this connexion it must be urged that it is seldom that a patient cannot be tided over with an infusion of dextran[1] or plasma while the results of these extremely important tests are awaited.

These ideals cannot always be attained, even in areas where modern laboratory facilities are available; for instance, at night the laboratory is often closed. There are also ultra-acute cases where a delay of even two hours may turn the scales against the patient. Sometimes surgeons practising in an area where full laboratory facilities are available are unmindful that there are colleagues placed in circumstances where blood transfusion must be carried out in the absence of these facilities. Therefore, in this book emphasis will be placed on methods to be followed when laboratory facilities are at a low ebb, meagre, or absent.

[1] A sample of blood for grouping, Rh typing, and cross-matching must be taken *before* an infusion of dextran is commenced (see

4 PROCEDURE WHEN FULL LABORATORY FACILITIES ARE AVAILABLE

Obtaining Specimens of Blood

Collecting a Sample of Serum from the Recipient.—Two or 3 ml. of blood is removed from a small vein (not one that may be required for transfusion) with a dry sterile or freshly boiled syringe rinsed in sterile normal saline solution. A syringe stored in spirit or other antiseptic must never be employed for this purpose because antiseptics are liable to hæmolyse the blood. For the same reason the blood must not be squirted through a fine needle into the container the needle should be removed from the syringe before ejecting the blood. Clotting occurs in about 20 minutes, and more readily if the tube is kept slightly warm, as in the pocket. Supernatant serum is then available for cross-matching against the donor's red cells.

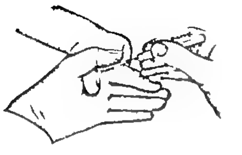

Fig 77 —Method of a fingertip hold in order to obtain a drop of blood. (*After Riddell.*)

Obtaining a Drop of Blood from the Donor or Recipient in order to make a saline suspension of red cells (*see below*) or for bedside cross-matching (*see* p 44) the lobule of the ear or a finger towards the tip (*Fig* 77) is the most convenient site In an infant a heel-stab is the best In all cases the prick of a straight cutting needle is used.

Collecting Blood for the Presence of Hæmoglobin or its Derivatives in the Plasma.—Precautions regarding sterilization of the syringe and needle given above must be observed in addition the syringes must be dry The blood is run into the tube slowly but the test tube must contain a few oxalate crystals or 2 mg of dry heparin. The test tube is inverted two or three times to ensure mixing A specimen of blood collected in this way is required for the spectroscopic diagnosis of hæmolysis (see p. 68).

ABO Grouping

1 A suspension of red cells of the person to be tested is prepared in the following way with a teat-ended pipette or a hypodermic syringe, 50 drops of normal saline solution are placed in a small agglutination tube 50 × 7 mm. in size One large drop of blood obtained from the donor or the recipient, as the case may be, is conveyed to the tube containing this saline solution.

2. Each of two dry and empty agglutination tubes labelled respectively A and B are taken and into each is placed one drop of the suspension of red cells.

3. To tube A add one drop of anti A serum To tube B add one drop of anti B serum.

4 The tubes are capped and left at room temperature for one hour

5. One drop of the sediment from tube A is conveyed to a slide marked A, and with a clean pipette one drop of the sediment from tube B is conveyed to a slide marked B and each is examined microscopically (*Fig* 78).

Rhesus Typing

The simplest method is to use serum containing saline agglutinins. One volume of saline red-cell suspension is mixed in a small test tube with one volume of Rh anti D serum. The tube is capped and incubated at 98·6 F (37° C.) for two hours. The deposit is drawn up into a Pasteur pipette spread on a slide and examined microscopically If the cells have agglutinated, the blood is Rh-positive if no agglutination has occurred the patient is Rh-negative. The scarcity of serum containing saline agglutinins makes it necessary to employ anti D serum containing albumin agglutinins the technique of using the latter is beyond the scope of this book.

Compatibility Tests

The final criterion is a direct compatibility test using the recipient s serum and the donor s cells. A drop of the recipient s serum is added to a 2 per cent suspension of the donor s red cells, and incubated at 98·6 F (37° C.) for two hours, as also another similar

specimen at room temperature. Another drop of saline suspension of cells is centrifuged. The supernatant fluid is removed and the cells are re-suspended in 20 per cent albumin. One drop of the recipient's serum is added. This tube is also incubated for two hours.

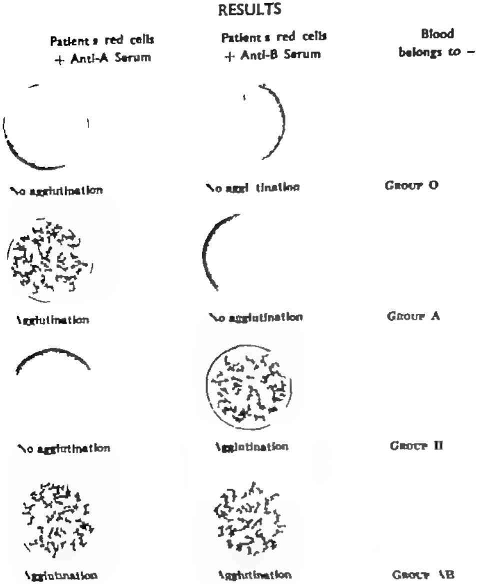

Fig 78.—Chart showing method of identifying the different blood groups.

After incubation a specimen from each tube is examined microscopically. If the donor's cells are compatible with the recipient's serum no agglutination will have occurred. Direct matching also involves carrying out an anti human-globulin (indirect Coombs') test, to detect those rare antibodies which are capable of sensitizing but not agglutinating, red cells carrying the corresponding antigen. The technique of the test is beyond the scope of this book.

B METHOD WHEN PRESERVED BLOOD CAN BE OBTAINED BUT THE SERVICES OF A PATHOLOGIST ARE NOT AVAILABLE FOR SOME TIME

A Simplified Method of Grouping Blood (R. A. Zeitlin).—This consists in using only group O Rh negative and group A Rh negative bloods for emergencies, and disregarding groups B and AB in the recipient. To type the patient only one serum—anti A—is required. A positive result (agglutination) means that the patient belongs to group A or group AB, and in either case group A Rh-negative blood can be used. A negative result

(no-agglutination) types the patient as belonging to group B or O for either of which group O Rh-negative blood must be used.

By using only one serum for grouping and only group O Rh negative or group A Rh-negative blood for emergency transfusion, the catastrophes of incompatible transfusion are circumvented.

Summarizing If the patient belongs to groups A or AB give group A Rh negative blood If the patient belongs to groups B or O give group O Rh negative blood.

The technique can be simplified further by the use of ordinary microscope slides coated with potent anti A serum, and protected with polythene adhesive (*Fig* 79). Such

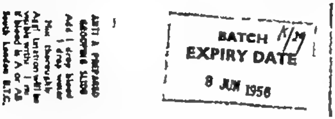

Fig 79.—Anti A prepared grouping slide

slides, stored at ordinary refrigerator temperatures, remain fully active for three months. They can be used without any special apparatus, and one drop of tap water and one drop of blood are mixed on the slide Macroscopic agglutination is obtained in one minute or less in groups A and AB

As soon as laboratory facilities are available ABO and Rh typing should be carried out in the laboratory so that transfusion with homologous blood can continue, if necessary

Blood banks are usually short of group O Rh negative blood and it is sometimes necessary in the first instance to transfuse males who have never had a previous blood transfusion or intramuscular injection of blood with Rh-positive blood because of such shortage It should be noted particularly that this applies only to males, and such a transfusion should not be continued for more than two successive days. If it is probable that an Rh-negative male will require multiple transfusion Rh positive blood should not be used.

C PROCEDURE IN THE ABSENCE OF A BLOOD BANK AND OF SERA FOR TESTING

Procure the services of several potential donors. If possible six should be available in order to minimize delay in obtaining a sufficient quantity (2 or 3 bottles) of blood compatible with that of the recipient

Bedside Cross-matching.—The most practical bedside technique for cross-matching is as follows Take a white dinner plate Warm it under running hot water and dry it carefully (a white opal glass tile has the ideal surface for this test) On the inverted plate or tile place three drops of the patient's serum obtained as described on p 42. The drops are removed from the test tube with a platinum loop or a glass rod. Two drops of the donor's blood, obtained as described on p 42, are transferred and placed on the plate alongside the pool of serum. The blood and the serum are then mixed thoroughly by stirring with the platinum loop this mixing produces a strong pink coloration of the whole pool The plate is rocked from side to side for about a minute One then waits a further minute—two minutes in all. Incompatibility will be seen by agglutination that is evident to the naked eye but can be made more obvious by using a magnifying glass. To wait longer than two minutes is to confuse the issue by the periphery of the mixture becoming dry this produces a concentration of red cells in the centre of the pool and the phenomenon of pseudo-agglutination results. At the end of two minutes, if there is uncertainty repeat the tests should uncertainty still prevail, obtain another donor When, because of lack of the necessary stock sera bedside cross-matching alone can be employed, it is safest to follow this rough test which can be relied upon to exclude gross incompatibilities, with —

The Biological Test.—Fifty ml. of a donor's blood negative to the above test is transfused very slowly taking 30 minutes for this small amount to be administered The patient is watched closely for the whole period, and should any untoward symptom develop the

transfusion is stopped immediately When no reaction occurs during that time it is concluded that the blood is compatible and the transfusion is continued at the desired rate

STORED BLOOD

The anticoagulant most frequently used is —

Disodium citrate (monohydrate)	2 5 G
Dextrose anhydrous	3·0 G
Pyrogen-free water	to 120 ml.

To this amount of anticoagulant in a blood bottle is added 420 ml of blood, making the total contents 540 ml

If it is to be preserved within 30 minutes of collecting it blood must go into cold storage The correct cold storage temperature is + 4 to + 6 C., which is maintained by a refrigerator especially regulated for the purpose Freezing must never be allowed to occur because this causes hæmolysis.

For how long can Blood be stored safely?—After 14 days preserved blood commences to deteriorate in that an increasing percentage of red cells becomes unduly fragile con sequently if the contents of two or more such bottles of blood are given to an enfeebled patient with poor renal function a hæmolytic reaction with urinary suppression occasionally supervenes. With this exception blood preserved with acid-citrate-dextrose solution can be given without danger due to age up to 21 days after withdrawal.

It should be noted carefully that blood preserved by plain sodium citrate should never be stored for more than 7 days.

There is no gainsaying that in some respects stored blood is inferior to fresh blood. For one thing its bactericidal properties are less, and the possibility of infection unknown in the transfusion of freshly-drawn blood, is a source of potential danger Perfection in methods of sterilizing of apparatus and preserving fluids have reduced the danger almost to vanishing point. The recently introduced pilot bottle (*see Fig* 110 p. 06) for obtaining a specimen of blood for cross-matching without entering the main bottle has been added to prevent the last remaining obvious possible source of infection No less than 750 000 bottles of stored blood were used in Great Britain in 1955

Plastic containers, instead of glass bottles, are on trial. The material from which the containers are constructed has to be supervised rigidly and pass many tests, for some plastics can cause blood to deteriorate The advantages of plastic containers are their lightness, they do not break readily and pressure can be applied to them to overcome veno-spasm.

THE INDICATIONS FOR TRANSFUSION

Throughout the chapters that follow when blood transfusion is necessary the reason for the step the time at which it should be undertaken and other relevant details are described. Here it can be stated that indications for transfusion in urgent surgery are almost confined to severe hæmorrhage and profound shock. As will be explained in Chapter VII in shock *per se* transfusion is not essential during the first two hours, for plasma or dextran infusion suffices while compatibility tests are being undertaken. In the case of severe hæmorrhage blood (or a suspension of red cells) is sometimes needed extremely urgently because the oxygen-carrying erythrocytes have fallen to a low level

Exsanguination.—The normal blood volume of a man of 10 st. (63.5 kg) is 10 pints (5·6 L.) Exsanguination may be divided into three stages —

Moderate exsanguination	Hæmoglobin 50 per cent
Severe exsanguination	Hæmoglobin 35 to 50 per cent.
Terminal exsanguination	Hæmoglobin under 35 per cent the fatal issue being determined by anoxæmia of the vital cells.

Useful as is the hæmoglobin estimation especially in conjunction with red-cell counts and hæmatocrit readings, it must be stated categorically that in the *early hours following* a severe hæmorrhage hæmoglobin estimation (and other laboratory investigations of the blood) are of absolutely no value as a guide to the necessity for transfusion, seeing that at

least three to four hours elapse before hæmodilution occurs. The need for transfusion and the amount of blood required must be assessed on the history and physical signs, including the blood pressure.

Patients in the second and third stages of exsanguination are usually drowsy and stuporous. Probably cerebral œdema plays a part in these mental changes. This is brought about by the time-honoured custom of laying the patient flat and elevating the foot of the bed. The head becomes the most dependent part and there is impairment of venous return. These patients are far happier if their head is elevated upon one or two pillows (L. J. Wood).

The question arises whether blood transfusion should be used in the case of bleeding from a large vessel before it is possible to ligate the vessel. Recent investigations have shown that there is no risk in starting a new hæmorrhage or dislodging a possible hæmostatic clot by transfusion as early as possible even before the vessel can be ligated or repaired (Mayo and Jenkins).

TRANSFUSION OF STORED BLOOD

Recognition of Stale Blood.—Every bottle of blood that has been supplied from a blood bank should be examined critically.

On storing preserved blood settles into its constituent layers (*Fig.* 80). The red cells pass to the bottom of the bottle and are separated from the plasma by a layer of leucocytes. The supernatant plasma should be lemon yellow or light-amber coloured

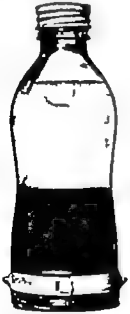

Fig. 80.—Stored blood, showing supernatant plasma.

Fig. 81.—This bottle of blood should be discarded.

the latter is more usual with the modern anticoagulant. In any case the supernatant plasma should be tolerably clear. Cloudiness may be due to the presence of lipoids ingested by the donor before withdrawal of the blood. It is to prevent an undue lipoid content that donors are asked not to have a fatty meal within four hours of giving blood.

It is highly important to note the colour of the supernatant plasma. An unmistakable red tinge signifies that hæmolysis of erythrocytes has occurred. Such hæmolysis may be due to: (a) Infection. (b) Age, i.e., over twenty-one days of storage. (c) Freezing—stored blood should not be frozen, but kept at 35° to 39° F. (2° to 4° C.). (d) Warmth—the blood should not be removed from the refrigerator or insulated container until shortly before use.

Discard any bottle of blood which shows indisputable signs of hæmolysis (Fig. 81) or undue cloudiness.

Temperature of the Blood.—As a rule there is absolutely no need to heat blood before administering it. Gravitation of the blood at room temperature is perfectly satisfactory. Even if the bottle is very cold, by the time the blood has gravitated through the tubing it will probably be of a temperature approximating that of the room.

Filters.—Owing to separation during storage of small amounts of fibrin and lipoid material, preserved blood requires to be filtered before being given to a patient. Two main types of filter are in common use:—

a. The gas-mantle filter (*Fig.* 82) is extremely efficient, but it has to be renewed every time the apparatus is used.

b. The metal gauze filter (*Fig.* 83) is almost indestructible, and is just as efficient as the gas-mantle filter.

Fig. 82.—The gas-mantle filter.

Fig. 83.—The metal gauze filter.

In the absence of either of these filters:—

c. A medicine glass full of sterile glass beads poured into the bottle acts admirably, and has the advantage of absolute indestructibility.

d. Filtration through six thicknesses of sterile gauze before pouring the blood into the receptacle is absolutely efficient, as I have been able to demonstrate on many occasions. This method should only be employed in the absence of other filters, as it involves exposure of blood to the air.

The Administration.—The technique of the administration of preserved blood is shown pictorially in *Figs.* 84–89. With the standard giving-set the time taken for the contents of a bottle of blood (540 ml.) to gravitate into a vein of the patient can be predicted approximately from the following table:—

30 drops a minute			5 hours
40	,,		4 ,,
60	,,		2½ ,,
200	,,	(just countable)	45 minutes

Changing Bottles.—When the bottle is nearly empty the rate of flow through the drip chamber is slowed down in order to allow plenty of time for the empty—or rather, nearly empty—bottle to be changed for a full one. A hæmostat is clamped on the tubing above the drip chamber. The next duty is to verify that the label on the full bottle states that the blood contained therein is the correct ABO group and Rhesus type for the patient. The screw cap is removed by the nurse while the medical officer (or, in his absence, the sister-in-charge), duly scrubbed up and masked, unhooks the empty bottle from the stand on which it is hanging, removes the rubber cork with the filter and the air-inlet tube attached, and inserts it firmly into the mouth of the full bottle. The bottle is hung upon the stand, and the hæmostat is removed. The transfusion continues.

Fig 84.—In order to mix the constituent of stored blood it is only necessary to invert the bottle twice. The screw cap is then removed.

Transfusion of Stored Blood

Fig. 85.—The transfusionist takes the filter and attached tubing out of the sterile bag.

Fig. 86.—The perforated rubber cork with its attached tubing is plugged into the bottle firmly; the nurse ensures that the cork is driven home by giving the bottle a half turn. She then inverts the bottle and

Fig. 87.—hangs it on a stand. This completed, she applies a hemostat to the tubing above the interceptor and unscrews the screw clamp completely.

Fig. 88.—The nurse releases the hemostat and blood issues from the needle. In this way all air in the tubing is quickly expelled. She re-applies the hemostat to the tubing. The transfusionist holds the needle or cannula above *the level of the table and he catches blood issuing* from the needle with a swab.

Fig. 89.—The needle or cannula having been inserted into the vein, the self releasing tourniquet having been dropped and the hemostat removed from the tubing, blood is flowing rapidly into the vein. The needle is fixed in position appropriately. *It is now only necessary to adjust* the number of drops passing through the interceptor.

Alternative Method.—When long-continued drip transfusions are given from standard blood bottles the risk of infection is probably small but it is still possible to introduce organisms when one bottle is changed for another. The risk can and should be reduced by changing the giving set at the same time as the bottle. The needle or cannula is left in the vein, and the giving sets are plugged into the adaptor near the vein (Mollison). During the changing of bottles plus the receiving sets, a tourniquet should be applied to the upper arm to prevent the possibility of air being sucked into the open end of the vein cannula.

When a cannula is being used the tubing cannot be disconnected easily from the cannula, and such manipulations are likely to displace the cannula. In these cases the giving set is best disconnected immediately above the drip chamber a hæmostat having been applied to the tubing a short distance below the drip chamber. The tubing having been disconnected similarly from the new giving set the rubber cork is plugged into the fresh bottle and its tubing clamped. The bottle is then inverted and the hæmostat is released and quickly re-applied so as to evacute air from the tubing. The full bottle with its own fresh filter with attached tubing is hung on the stand and the original interceptor is attached to it. Both hæmostats are removed.

If changing bottles entails renewing the giving set or any part thereof it should always be undertaken by a medical officer.

Difficulties at the Commencement of the Transfusion.—

The Blood will not flow into the Vein or does so very slowly.—The possible causes enumerated below should be investigated in the following order and dealt with:—

1. Has the tourniquet been removed? Is there constriction above the elbow from a rolled up sleeve?

2. Is a cork (see *Fig.* 83) or a tight cotton wool filter occluding the air inlet to the blood bottle?

3. Is there an air lock in the rubber tubing? This cannot happen if the technique depicted on p. 48 is followed.

4. Has the needle or cannula become angulated?

5. Venospasm.

The last requires detailed consideration. It is particularly liable to be present in patients suffering from shock, hæmorrhage or both and it is in these cases that it is sometimes so necessary to speed up the transfusion. When venospasm is much in evidence it will obstruct the flow of blood along the vein below the elbow or the knee because blood is more viscid than other fluids used in intravenous fluid therapy. Venospasm is liable to be increased by giving cold blood straight from the refrigerator and is especially troublesome in the small veins of infants, where it can stop a transfusion entirely.

Methods of overcoming Venospasm.—

a. The blood should be raised to the full height the tubing will allow (about 9 ft.) and hot water bottles are laid along the limb.

b. If the need for blood is imperative the best expedient is to cannulize a second vein and into it gravitate dextrose-saline solution, followed by plasma or dextran. In many cases this will increase the blood volume and release venospasm sufficiently to allow the blood to drip freely into the vein first cannulized. In desperate cases the infusion can be given into the bone-marrow of the sternum (see p. 17). This is far less dangerous than employing:—

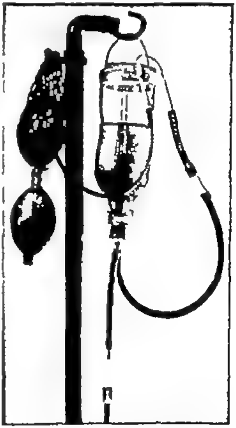

Fig. 90.—If positive pressure is employed, a U-tube containing a cotton-wool filter should be included in the tubing of the pump, to prevent air-borne bacteria entering the flask. All pumping must cease when the bottle is two-thirds empty. (*J. P. Bull and L. Hurst.*)

c. Positive pressure. Although many transfusionists have called attention to the fact that blood can be administered rapidly by the use of positive pressure obtained by pumping air into the transfusion bottle via the air inlet by means of a Higginson's syringe or a sphygmomanometer bulb and its attached tubing, this method carries the very definite danger of air embolism. A further objection to this method is that particles of fibrin may be forced through the filter into the recipient's circulation. If the transfusionist feels that this method of pumping the blood into the circulation is essential in a given case, then he must do it himself, and never relegate it to an inexperienced house surgeon or a nurse. What is of paramount importance is that no further positive pressure should be used after the flask is two-thirds empty (*Fig.* 90) and the delivery tube should be clamped with a hæmostat when the contents of the bottle sinks to the level of 2 in. (5 cm.) above the upper end of the air inlet, that is to about the level of the shoulder of the bottle. (See also the danger of the optical illusion caused by a blocked filter (*Fig.* 144, p. 100).)

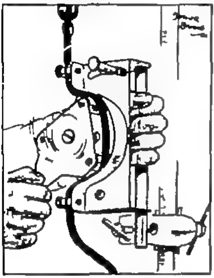

Fig. 91.—Martin's pump in use.

Martin's Pump.[1]—The mechanism is based on the principles of rollers compressing a collapsible tube (*Fig.* 91). To apply the pump it is unnecessary to detach any part of the tubing from the transfusion apparatus. The tube is held in place by two clips, and the pump is easily and quickly attached and detached as required. By this method a pint of blood (568 ml.) can be given in about 1½ minutes. Especial care must be exercised not to employ the pump if there is uncertainty as to whether the tubing has been punctured (by giving intravenous injections into it) (see AIR EMBOLISM, p. 100).

Acceleration of the flow of blood by any means other than raising the bottle to the fullest extent of its attached tubing is seldom, if ever, required if the cephalic vein is cannulized in the manner described on p. 18.

Difficulties during Transfusion.—

Frothing in the Drip Chamber (*Fig.* 92 B).—This sometimes obscures the flow of drops. Frothing can be eliminated by injecting one minim of anæsthetic ether into the drip chamber in the same manner as shown in *Fig.* 29, p. 10.

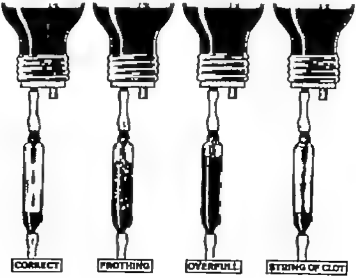

Fig. 92.—Reasons for the flow of drops through the drip chamber becoming obscured.

[1] Made by Allen & Hanburys Ltd., London.

Drip Chamber over filling (*Fig* 92 C)—Can be remedied as shown in *Fig* 20 p. 10

String of Clot obscuring the Flow of Drops (*Fig* 92 D)—The giving set must be changed.

Slowing or Stopping of the Transfusion—The possible causes enumerated below should be investigated in the following order and remedied —

1 *Displacement of the hollow needle*: The prevention of this complication has been dealt with on p. 14

2. *Occlusion of the needle or cannula with blood-clot* is more liable to occur in very slow transfusions and calls for removal of the needle or cannula, dislodging clot and reinsertion into another vein. In extensive clotting it is better to replace the needle or cannula with a fresh one

3. *Filter blocked*: This dangerous condition should be suspected if the flow stops when the bottle is about three-quarters empty If on changing bottles, slime or clot is seen on the filter most certainly a fresh giving set should be employed.

4 *Thrombophlebitis*: If any redness is seen along the course of the vein, the needle or cannula should always be changed to another vein without attempting to restart the flow The site of the original puncture or incision is covered with a dry dressing

NURSING INSTRUCTIONS

The general instructions embrace those set out for intravenous infusions, p 31 In addition —

1 *Take the temperature half hourly and report if the temperature rises one degree* or more if the patient shivers, or has a rigor If a rigor occurs stop the transfusion and call the medical officer If the temperature rises one degree reduce the rate of the transfusion and report to the sister in-charge

2. Chart all urine passed and the time of passing

3 When altering the rate of flow it is a good practice to run the blood at full rate for a few seconds before adjusting the screw-clamp so that the prescribed number of drops pass through the drip chamber each minute

4 If the drip slows down and cannot be remedied by adjusting the screw-clamp call the medical officer

5 If the drip chamber becomes overfull, or there is a string of clot hanging from where the drops should fall, and for one of these reasons you are unable to count the drops call the medical officer

6 When the blood in the bottle has emptied to within 2 in. (5 cm.) of the cork, apply a hæmostat to the tubing and call the sister in-charge at once.

7 Always verify that the new full bottle is for that particular patient.

8 The sister if experienced in blood transfusion, can change the empty bottle for a full one. For this procedure the sister and the nurse should scrub up, and the sister should be masked and preferably gloved. *Changing the bottle is carried out as in Fig 86.* The cork and fitting, and the tubing attached thereto, are transferred from the empty bottle to a full one.

CONCENTRATED RED CELL SUSPENSION (PACKED CELLS)

Indications.—In patients suffering from severe anæmia, but possessing a normal blood volume, the administration of a concentrated suspension of red cells has the advantage that the blood-volume is increased but slightly and the deficient factor alone is added to the blood stream. Consequently the dangers of overloading the circulation are considerably reduced.

Preparation.—To provide sufficient to fill one bottle, it is convenient to pool the concentrated red-cell suspension from two bottles of blood. One method of preparation, now only used in a nocturnal emergency is to wait until the red cells have settled spontaneously and then to open the bottle and pipette off the supernatant plasma. A better method is to remove the cells from two bottles by the closed method (*Fig* 93).

When the suspension is prepared by the first method described, the risk of infection at the time of removal of the plasma is such that the suspension must be used immediately If prepared by the second method, the suspension can be stored for 24 hours, but must be kept in the refrigerator until 20 minutes or half an hour before using The suspension should never be warmed before use.

Special Details concerning the Transfusion of Packed Red Cells.—The fluid, being more viscid than stored blood, must be given slowly and should be administered at the rate of 30 to 40 drops a minute. The vein into which the packed red cells is given is more likely to thrombose than when whole blood is administered.

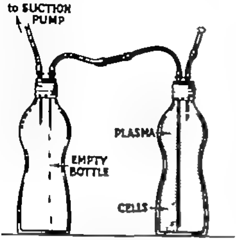

Fig 93.—The closed method of withdrawing cells from a st ndard bottle of blood.

I have made considerable use of packed red cells in cases where blood loss had rendered the patient severely anæmic but the blood pressure remained satisfactory and in those with poor renal function where as a consequence a transfusion reaction was to be feared

E. D., aged 71 was admitted with retention with overflow of six months duration, due to an enlarged prostate. He had a blood-urea of 120 mg. per cent. The bladder was decompressed slowly and on the following day the urine became excessively blood-stained. He continued to bleed, and between the first and third post-operative days the hæmoglobin fell from 72 per cent to 55 per cent. One pint of packed red cells was administered, and by the evening the hæmoglobin had risen to 90 per cent After the transfusion of packed red cells the patient felt much better and his general condition improved appreciably

H Chaplin s Case —A boy aged 9 was admitted in a poor condition following an abdominal injury due to a street accident He was given a transfusion of 500 ml. of group O Rh-negative blood without preliminary grouping or cross-matching A rupture of the right kidney was diagnosed, and while 500 ml. of plasma was administered, nephrectomy was performed. Blood grouping was then carried out, and it was found that the patient belonged to group A and was Rh-positive. It was desired to give him a further blood transfusion, but it was found that, because of the previous O transfusion, there was so much anti-A iso-agglutinin present in his blood that no compatible donor could be found. About this time the patient developed hæmoglobinuria, and the need for blood transfusion became more urgent. He was transfused with washed packed group O red cells, without incident. Recovery

TRANSFUSION OF FRESH BLOOD

Preparation of Citrate Solution.[1]—Citrate solution of the necessary concentration (3·8 per cent) can be obtained in ampoules ready for use (*Fig* 94). This saves time and anxiety If the solution is not available in this form, it must be made up freshly for each transfusion. When sodium citrate crystals are used, 2 G of the salt is deposited in the sterile collecting flask to this 100 ml. of warm sterile water is added. There is now in the flask sufficient anticoagulant fluid for one pint of blood.


Fig 94 —Ampoule of 3 8 per cent sodium citrate. (*Evs Medical Supplies Ltd.*)

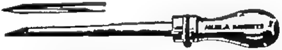
Fig 95.—French s bayonet-ended tapering blood-collecting needle.

Apparatus for Collecting the Blood.—A hollow needle with a wide bore (*Fig* 95) is examined. If the point is not sharp, it is touched up upon a hone. To the base of the needle 8 in. (20 cm.) of soft rubber tubing is affixed The needle and the tube are wrapped in a piece of gauze and sterilized by boiling in citrate solution. It is advisable to be provided with two such needles and tubing If a special blood-collecting bottle is not available it is a simple matter to improvise one, after referring to *Fig* 96.

Collecting Blood from the Donor—It is neither justifiable nor is it necessary to cut down upon a vein of a member of a

[1] Richard Lewisohn, of New York, perfected the citrate method in 1915, thus conferring a great benefit on humanity

transfusion service; indeed this is contrary to the rules of these associations. When the donor is a relative or friend of the patient and the veins are relatively inconspicuous, an exception may be made. In such circumstances a vein below the elbow may be exposed and a cannula inserted after the manner shown in *Fig* 31 p. 11. In this way a pint of blood is collected quickly.

A Standard Method of Collecting Blood. Examine the fold at the elbow on both sides and choose the side with the most prominent vein. If the veins are comparatively small get the donor to hold his arm in a jug of hot water for five or ten minutes with the water as hot as can be borne comfortably. This is an effective method of producing vasodilatation.

The donor lies upon the table allowing his arm to hang down. The cuff of a sphygmomanometer is placed around the arm as high up as possible. *The cuff of the sphygmomanometer is inflated until a pressure of between 30 and 60 mm. Hg is registered.* An assistant is detailed to watch the dial of the instrument and to maintain a constant pressure of 40 mm. At this pressure veins are occluded but the arterial supply is unimpaired.

Fig 96.—A stored blood bottle adapted for collecting fresh blood.

The arm rests upon a side table and while final arrangements for collecting blood are being made the donor slowly opens and closes his hand. The skin about the antecubital fossa is sterilized with alcohol. A pad in the form of a folded towel is placed behind the elbow in order to extend the joint fully. The surrounding area is draped with sterile towels. The operator sits down. The patient is told to stop opening and closing the hand and to keep the arm steady. All is in readiness for the puncture.

Fig 97.—Collecting blood. Inserting the needle into a vein.

With a hypodermic syringe fitted with an intradermic needle one drop of local anaesthetic is injected into the skin over the vein. The weal produced is massaged gently with a gauze swab. As soon as the vein is again clearly apparent unless the operator is very experienced a tiny incision in the skin should be made.

The needle is thrust into the subcutaneous tissue (*Fig* 97). The point of the needle is then made to enter the vein from a lateral aspect. The sensation of a clean entry into the lumen of a vein is characteristic. (*Fig* 98.)

The collecting flask is placed on a table or chair and the blood drips or flows steadily into the flask and the citrate solution contained therein (*Fig* 99). There is no need to agitate the bottle in an attempt to mix the blood and the citrate solution, but gentle rocking is permissible.

Should the flow of blood lessen the donor is asked again to open and close his hand. If everything is in order these muscular contractions speed the flow of blood. It should be unnecessary to add that during the whole of the operation the surgeon is steadying the needle. If these details are adhered to strictly there is seldom any difficulty in collecting a pint of blood in a short time.

As soon as the desired quantity of blood has been obtained, the sphygmomanometer is deflated and the hollow needle removed from the arm which is dressed and bandaged.

Difficulties.—The flow of blood becomes feeble or stops. Provided the donor is still in good condition this signifies a mechanical stoppage. Ascertain that the sphygmomanometer is functioning and is registering a pressure of 40 mm. Hg. Very cautiously withdraw the needle a millimetre or two and if necessary alter the angle at which it enters the vein. If this does not produce the desired result, push the needle in a little farther. When all these expedients have failed, it is probable that clotting has occurred in the needle or the tube. There remains only one practical course to pursue. Deflate the sphygmomanometer and remove the needle and tube. Take the spare needle and tube and, using the same technique as before, puncture another vein, preferably but not essentially in the other arm.

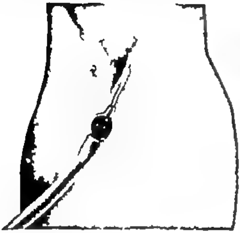

Fig. 98.—Collecting blood. The needle in situ.

Fig. 99.—Collecting blood. The process in operation.

After-care of the Donor.—It is remarkable how little a healthy individual is affected by the loss of a pint of blood. He must not, however, resume the upright position immediately. A hot drink, or if he prefers it, some alcohol, is given. The donor should report on the following day for inspection of the arm.

Administering the Blood to the Recipient.—This is conducted in exactly the same way as the administration of preserved blood.

TRANSFUSION OF FRESH BLOOD, USING A TRANSFUSO-VAC[1]

The Transfuso-vac is a very valuable apparatus for performing blood transfusion. It possesses certain advantages.

a. The transfusion can be carried out anywhere, even under the most unfavourable conditions.

b. As the flask contains the correct amount of citrate solution, time and trouble are saved.

c. The blood is withdrawn and administered without being exposed to the outside air.

Collecting Blood with a Transfuso-vac

The Apparatus consists essentially of a flask containing the appropriate amount of sodium citrate solution (*Fig.* 100). Within the flask there is a partial vacuum.[2] For withdrawing the blood a special perforator is provided and this is connected to a length of rubber tubing. To the distal end of the tube a hollow needle, which is also provided in the outfit, is attached.

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[1] The Sterivac equipment (Allen & Hanburys) and the Veno-flask (British Drug Houses) are practically identical, and a description of the technique of the Transfuso-vac covers both these sets of apparatus.

[2] The only danger of this apparatus is that very occasionally the partial vacuum is lacking due to faulty manufacture. Tubing that dimples at one spot if the negative pressure is satisfactory is being supplied with some of these apparatuses. It is a great safeguard against air embolism.

Withdrawing the Blood.—The metal cap of the flask is removed and the rubber diaphragm with its underlying rubber stopper is pierced by the special perforator in the manner

Fig. 100.—The apparatus. A Transfusovac, the special perforator with attached tubing, together with hollow needles and a special spanner.

shown (*Fig.* 101). The apparatus is now ready for the reception of the blood. The knob controls the rate of suction (*Fig.* 102) and this should not be turned until the needle is

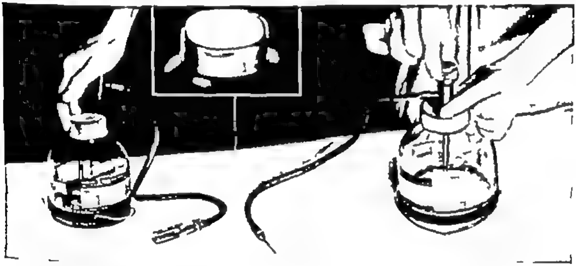

Fig. 101.—The metal cap having been removed, the rubber stopper is then pierced with the special perforator. The X (inset) shows the point at which the rubber stopper should be pierced.

Fig. 102.—This knob controls the rate of suction. It must not be turned until the needle is in the vein of the donor.

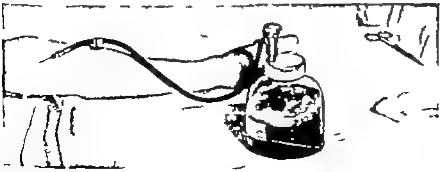

Fig. 103.—Blood entering the flask. The screw-clamp is fully open. A pint is soon collected.

within the donor's vein. The vein is entered in the usual manner and the knob is turned and blood will flow into the flask. The knob is adjusted so that blood flows steadily into the flask. In ordinary circumstances a pint of blood is collected in a few minutes (*Fig.* 103).

Administering the Blood to the Recipient.—The perforator is removed from the stopper and the rubber cap is cut away aseptically (*Fig* 104) The special interceptor is inserted through the perforation in the rubber cork (*Fig* 105) in the same manner as in the well

Fig. 104 —The flask now contains pint of blood. The perforator having been removed, the rubber diaphragm is removed aseptically

Fig 105 —Inserting the interceptor through the perforation in the rubber cork.

known Vacoliter for the administration of intravenous saline The flask is inverted and hung upon a convenient stand, and the blood is administered to the patient in the same way as stored blood (see p. 48)

THE TRANSFUSO-VAC PRINCIPLES APPLIED TO THE BOTTLE USED FOR STORED BLOOD

Into a sterile bottle used for stored blood is poured 120 ml. of citrate solution (preferably with 2 5 G of dextrose added) The rubber diaphragm is placed within a perforated aluminium screw cap (*Fig* 106) The cap is screwed home tightly and then loosened half a turn. The bottle is now placed in an autoclave at 15 lb. (6 5 kg.) pressure for half an hour Immediately after withdrawal from the autoclave the screw cap is tightened. As the

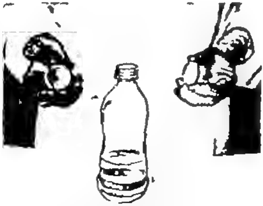

Fig 106 —Citrat solution has been placed in the bottle The rubber diaphragm is about to be inserted into the screw cap.

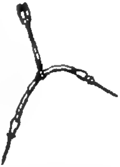

Fig 107 —One French's needle is inserted into the vein and the other through the diaphragm of the bottle

apparatus cools a vacuum is produced by condensation of steam that an efficient vacuum is produced is shown by the sucking in of the rubber diaphragm. A piece of rubber tubing 6 in. (15 cm.) long with a French's needle at each end which has been irrigated with citrate solution and clamped with a hæmostat (*Fig* 107), is all that is required to withdraw

the blood One needle is inserted into the vein and the other pierces the rubber diaphragm The hæmostat is removed and the blood flows into the bottle by virtue of the vacuum

DRIP BLOOD TRANSFUSION COMBINED WITH DRIP SALINE INFUSION

The sustained benefit of administering blood over a comparatively long period is sometimes advantageous. By employing this method it is possible to adjust the screw clamp so that a drop of blood alternates with a drop of dextrose saline and consequently the length of time over which the transfusion lasts is doubled Furthermore should there be delay in obtaining the requisite supply of blood the patient can receive intravenous dextrose saline or other parenteral fluid in the mean time In these long-continued transfusions one must be especially vigilant that each new pint of blood is cross matched It is wise to render the patient's urine alkaline and keep it alkaline during the period of transfusion.

When the apparatus has been assembled and air bubbles have been eliminated and the cannula inserted commence with the dextrose-saline As soon as this is dripping satisfactorily turn on the blood In an average case alternating drops at 30 per minute each is a good working rule which can be modified to suit particular requirements. This type of transfusion can be continued for days (*Fig* 108), when necessary but it is desirable to change the vein each twenty four hours.

Fig 108.—Drip-blood-saline transfusion in progress. Case of severe hæmatemesis and melæna.

RETROGRADE ARTERIAL TRANSFUSION

In a dire emergency if group O Rh-negative blood is available this can be given otherwise the strict rules concerning the use of correctly-matched blood apply

Indications.—

1 Serious hæmorrhage patient *in extremis*.

2. Profound peripheral circulatory hypotension (shock)

Blood is the only fluid that it is permissible to give intra-arterially Perfusion of any other fluid, because it is non-oxygen carrying imperils the life of the limb.

Retrograde Arterial v Rapid Intravenous Transfusion.— As can be surmised from the indications, retrograde arterial transfusion is a means of resuscitating desperate cases. Published reports prove that by its timely use recovery from extreme hypotension is often rapid and well sustained.

If in similar circumstances, rapid intravenous infusion (and or transfusion) is given, it is often followed by increased venous return and increased cardiac output but owing to the large amount of fluid introduced rapidly into the venous system, especially if it is given under positive pressure the right auricle and ventricle become considerably distended. In some instances overdistension injures the myocardium of the right side of the heart and, as a consequence when the intravenous infusion is concluded and the venous pressure falls, the heart's output into the pulmonary arteries declines and the patient's condition not only relapses into the pretransfusion state but worsens.

A much smaller quantity of blood given by the arterial route has as great or greater initial beneficial effect, and what is so important is that frequently the benefit is maintained for the following reason when the aortic semilunar valves close (should they be open the retrograde stream of blood under pressure will close them (*Fig* 109)) blood is forced into the coronary arteries as well as into the rest of the arterial system Not only is no strain put on the left myocardium, but the whole heart receives the benefit of the influx of blood into

the exposed artery. In cases of desperate urgency if the radial artery is found to be in a state of extreme spasm, this artery should be abandoned in favour of the brachial artery. As a rule in the case of the radial artery the use of a cannula is less difficult than the insertion of a hollow needle into a small artery; nevertheless, for reasons stated below every effort should be made to preserve the continuity of the artery. The needle or cannula is introduced into the artery with its free extremity directed towards the heart and when a cannula is employed the encircling ligature is tied securely.

When all is in readiness the tourniquet is removed and the transfusion is started by raising the pressure in the bottle by means of the bellows. If a sphygmomanometer is used the pressure should be raised to 150–160 mm. Hg. The same precautions to guard against air embolism as described on p. 40 must be taken. These precautions are unnecessary if the Oxford safety-drip (see Figs. 28 and 111) is in use. In cases of shock it is best not to give more than 2 bottles of blood intra-arterially. In exsanguination more may be required, for instance in the case of a wound of the heart when the patient had lost a great deal of blood. Pryor commenced by giving an arterial transfusion which was continued during the operation. Six pints (3·0 l.) were given by this route with remarkable and sustained benefit.

Difficulty. When the surrounding tissues have been infiltrated with procaine the radial artery of a collapsed patient is sometimes difficult to distinguish from the radial vein. In older patients tortuosity of the artery is a point of distinction. After inserting a needle or just before a cannula is inserted the tourniquet should be momentarily released in order that pulsatile flow can be observed. Omission of this precaution has led to cannulization of a radial vein in mistake for the artery (Danziger).

Dangers: In from 2 to 5 per cent of cases the radio-ulnar anastomosis as a palmar arch is *not present*. *In such cases, as a result of ligation of the radial artery, ischaemia of the radial half of the hand ensues.* Possibly in so great a percentage as 30 of those who have a congenitally inadequate collateral circulation between the ulnar and radial arteries, the baneful effects of interrupting the radial artery can be circumvented by injecting the stellate ganglion (see p. 1100) with 1 per cent procaine as soon as distinct pallor is noticed in the hand. If blanching cannot be remedied in this way gangrene of some part of the upper limb ensues. As a rule this is confined to the terminal phalanx of the index finger, but cases of gangrene necessitating amputation through the upper arm have occurred (Blakemore et al., Yee). Unquestionably the danger of ischaemia is considerably reduced by employing a method whereby tying the artery is obviated. J. E. Reet et al. recommend the use of a 15-gauge spinal needle cut off to within 1¼ in. (3 cm.) and having a blunt end. The stylet is ground to a sharp point which protrudes slightly beyond the end of the cannula. After the transfusion is concluded the cannula is removed and pressure is applied to the site of the puncture over a very small gelfoam pledget. This always controls bleeding from the puncture.

Intra-arterial Transfusion by the Femoral Artery.—For this purpose Neve has employed successfully a Greenfield's lumbar puncture needle (*Fig.* 112). In spare subjects a flat sandbag having been placed beneath the buttocks, and the thigh having been rotated externally the needle can be introduced into the artery percutaneously just beneath the inguinal ligament. If the artery cannot be palpated readily it is exposed by an incision over it. To puncture the artery the stylet must be withdrawn; the needle having entered the lumen of the artery in an upward direction blood spurts through the end of the needle whereupon the stylet is re-inserted quickly. The needle is advanced 1–2 in. (2·5–5 cm.) towards the umbilicus. The side-channel is now connected to the transfusion tubing. The stylet is again withdrawn and the tap is turned through 90° thus cutting off the open end of the needle and allowing the donor blood to be pumped into the artery through the side-channel. The operator steadies the needle while the transfusion is in progress.

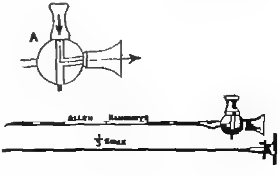

Fig. 112.—Greenfield lumbar puncture needle. A shows the mechanism of the tap.

BLOOD TRANSFUSION IN INFANCY

During infancy the avoidance of overtransfusion is imperative. The estimation of 10 ml. per lb. (454 G.) of body weight gives some indication of the quantity of blood that can be given safely. Another important principle is that for a female child Rh-compatible blood should be assured.

For rapid transfusion of a small amount of blood (up to 30 ml.) percutaneous puncture of a vein of the scalp with a needle connected to a Kauffmann's two-way syringe (*see Fig.* 33) is often satisfactory. While the injection is being given the infant must be recumbent, with its head held firmly by an assistant. On no account whatsoever must the superior longitudinal sinus be employed for transfusion or infusion. For drip transfusion the saphenous vein at the ankle or, if the patient is very collapsed, the saphenous vein in the middle third of the thigh (*see* p. 22) is the most satisfactory avenue. In the newborn transfusion is best undertaken by cannulizing the umbilical vein (*see* p. 23).

EXCHANGE TRANSFUSION IN ERYTHROBLASTOSIS INFANTIUM

In the great majority of cases of hæmolytic disease of the newborn, the mother is Rh negative and the increased rate of destruction of erythrocytes of the Rh-positive fœtus is due to anti-D passing through the placenta to reach the circulation of the fœtus. In a small minority it is not due to anti-D but to another antibody.

A proportion of infants die from erythroblastosis *in utero*; they are usually hydropic and seeing that the blood in the umbilical cord has an exceptionally low hæmoglobin content there is little doubt that they die from anæmia. Without treatment the mortality among infants with erythroblastosis that are born alive is very high (37 per cent). Some die of cardiac failure within 24 hours; others become increasingly jaundiced, and die comparatively suddenly about the third day from fixation of bile-pigments in the basal ganglia (kernicterus).

Indications for Treatment.—Until comparatively recently the diagnosis was made by the infant being born jaundiced, or becoming jaundiced usually within 24 hours after birth. At the present time Rh-sensitization of the mother can be detected during pregnancy by an examination of her serum for antibodies.

In such cases delivery should be undertaken in hospital, where, if necessary, exchange transfusion can be undertaken, as a rule between 4 and 6 hours after birth. In such circumstances the mode of procedure is as follows. The umbilical cord is clamped about 6 in. (15 cm.) from the abdominal wall as soon as possible after delivery. Using a dry syringe and a No. 1 needle the midwife or the doctor collects 10 ml. of blood from the umbilical vein on the maternal side of the clamp. Half the blood is transferred to a dry test tube for serological tests, and half into a test-tube containing dry anticoagulant for hæmoglobin estimation. *The criteria upon which the necessity for exchange transfusion is based are*:—

1. A cord hæmoglobin[1] level of 14·8 G. per cent (100 per cent Haldane), or less.
2. A hæmoglobin level of 17·7 G. per cent or less if the cord bilirubin content is 2·8 mg. per 100 ml. or more.

Time of Exchange Transfusion.—As has been stated, in most cases the optimum time is about 4 to 6 hours after birth. If delivery has been difficult, or the condition of the infant is poor for reasons other than hæmolytic disease, transfusion is best delayed up to 9 hours while the patient receives oxygen therapy. Conversely, if it is considered that the infant's condition is due to impending heart failure consequent upon the hæmolytic disease, the transfusion should be expedited.

Compatibility Tests.—As a rule Rh-negative blood of the same ABO group as the child is used. When urgency or lack of expert laboratory assistance prevents the necessary tests being performed, Rh-negative group O blood can be used.

Blood for Exchange Transfusion.—In order to provide the maximum number of erythrocytes in exchange for the infant's impoverished blood, blood with a hæmatocrit raised to about 55 per cent is highly desirable. *Either a bottle of fresh blood[2] is taken and centrifuged* or a bottle of blood 2–3 days old is selected; in either event 250 ml. of supernatant citrate-plasma is removed. For a baby weighing 8½ lb. (3·83 kg.) or under, two bottles of blood thus concentrated will be required.

[1] There is a great difference between the hæmoglobin content of the cord and that of the peripheral blood.

[2] Fresh blood is desirable; old stored blood raises the potassium content to dangerous levels.

Apparatus.—The essential component of the apparatus depicted in *Fig.* 113 consists of two-way taps machined in one block[1] with a large bore throughout. A 10-ml. syringe fits on one extremity and a cannula that fits 2 mm. bore polythene tubing is fixed to the other. One side-channel is connected to the tubing of the giving set; the other leads to an empty blood bottle without either filter or interceptor. Into the empty bottle is discharged the blood removed from the infant. The whole of the apparatus is sterilized by autoclaving except, of course, the polythene tubing. The bottles are suspended from transfusion stands, the bottle of blood having been placed in water at 98° F. (36·6° C.) for 15 minutes before use. The syringe, filled with a few ml. of citrate solution, is connected to the apparatus. The appropriate tap is turned on to allow blood to fill the tubing and flow from the open tap. After all air has been ejected from the tubing, the citrate solution is ejected through the open end, to wash the blood from the taps.

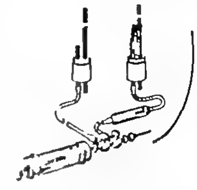

Fig. 113.—Apparatus for exchange transfusion. (*After Walker and Neligan.*)

Technique.—To keep the infant warm during exchange transfusion is of paramount importance. The baby is wrapped in gamgee, bandaged to a cruciate splint (*see Fig.* 020, p. 407), and laid upon a blanket. A hot water bottle having been placed on each side of the trunk, the blanket is tucked and pinned in such a way as to hold the hot water bottles in place, form a hood for the head, and leave the abdomen free. An assistant, usually a nurse, watches the baby's face, and is prepared to administer oxygen if required. She also records the amounts of blood exchanged during the whole procedure, notes the time taken for the exchange of each 100 ml. of blood, and is responsible for changing a nearly empty bottle for a full one when indicated. The umbilical vein[2] is cannulized as described on p. 23.

Measuring Venous Pressure.—As soon as the polythene tubing is satisfactorily in place within the umbilical vein, the external portion of the tubing is elevated and blood rises in its lumen. If the baby is quiet and relaxed there is a fluctuation of blood with each respiration. A pressure of 4 in. (10 cm.) or less is regarded as normal. If the venous pressure is high, 20 ml. of blood should be removed and replaced by 10 ml. in the manner about to be described. This is repeated until the venous pressure becomes normal.

Effecting the Exchange.—The blunt hollow needle is inserted into the polythene tubing, and its hub is connected to the tap. Ten ml. of blood is withdrawn from the infant, and, after turning the appropriate tap, is ejected into the empty bottle. This tap is closed, the other tap is then opened, and 10 ml. of donor blood is drawn into the syringe. With both taps in line, the blood is injected slowly into the infant. The cycle is repeated as often as is necessary to complete the transfusion, which proceeds at a rate of about 10 minutes for each 100 ml. exchanged. From beginning to end the transfusion of the two bottles of concentrated blood takes about 75 minutes, and effects an exchange of approximately 85 per cent of the infant's blood.

When the cord hæmoglobin is less than 7·4 G. per cent the transfusion should be carried out with a negative balance, even if the venous pressure is within normal limits. The amount not replaced is between 10 ml. and 30 ml.; the more profound the anæmia, the greater should be the negative balance. This will guard against circulatory overload and heart failure, to which grossly anæmic infants are peculiarly prone.

Complications during Exchange Transfusion.—

Heart Failure.—The infant becomes cyanotic and the blood withdrawn is dark in colour. Oxygen is administered and the transfusion rate is slowed considerably. If this does not effect early improvement, the polythene tubing is left in the umbilical vein, clamped with a hæmostat, disconnected from its cannula, and the baby is transferred to an oxygen-tent. If improvement occurs and the transfusion was grossly inadequate, it can be resumed after inserting a fresh polythene tube.

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[1] Medical Supply Association, Edinburgh. Silicone fluid D.C. 550 (Midland Silicones Ltd.) is used to prevent the taps and the plunger of the syringe sticking.

[2] In the rare event of this vein proving unsatisfactory, the saphenous vein in the thigh can be used.

Shock.—Mild shock usually passes off if the transfusion is slowed. Should the baby become pale and quiet, and its respirations shallow and rapid, the giving of 20–30 ml. of blood without withdrawing any usually results in rapid improvement.

Exchange transfusion performed in the manner described within nine hours of birth has reduced *the mortality of erythroblastosis infantium, which* untreated *is* 57 per cent to under 5 per cent.

UNTOWARD REACTIONS FOLLOWING BLOOD TRANSFUSION

One in two thousand blood transfusions is fatal (R. A. Zeitlin)

Reactions following blood transfusion are far from rare. Fortunately most of them are comparatively mild; nevertheless, serious or fatal reactions are still too frequent to permit a feeling of complete serenity while blood transfusion is in progress. It is also true, as will be explained later, that a number of deaths are directly due to over transfusion, and some of these are not recognized as such.

Almost invariably, catastrophic hæmolytic reactions appear very early in the transfusion. Therefore it is most advisable in every case to gravitate the first few ounces of blood slowly (25–30 drops per minute). In order to satisfy himself that the transfusion is agreeing with the patient, it should be an unwavering rule of every transfusionist to stay with the patient at least fifteen minutes after the transfusion has commenced.

Renal Disease.—Except, possibly, in cases where the patient's life is in jeopardy if he is not transfused forthwith, the urine must be tested before giving a blood transfusion. If possible, refrain from transfusing patients known to have damaged kidneys. If, for instance, the potential recipient suffers from nephritis, toxæmia of pregnancy, prostatic obstruction accompanied by a high blood urea, or blackwater fever with albuminuria, blood transfusion is more likely to terminate than to save life.

There are five varieties of untoward reactions due to blood transfusion :—

1. HÆMOLYTIC TRANSFUSION REACTIONS

These are the ones most to be feared. A hæmolytic reaction can be defined as the occurrence of an increased rate of destruction of erythrocytes of either the donor or the recipient. Such reactions can be avoided almost entirely by careful determination of the ABO group and Rh type of both donor and recipient, and proving compatibility by cross-matching. *Probably Rh incompatibility is the most common cause of hæmolytic* reactions to-day; nevertheless, there are occasional errors whereby, for one reason or another, the patient receives blood of the wrong group.

A hæmolytic reaction can be due to the destruction of the donor's erythrocytes or to lysis occurring in the recipient's red cells. The former is the more common, and by far th more dangerous. The causes of hæmolytic reactions are as follows :—

a. Transfusions of blood of the wrong ABO group.

b. The use of the universal donor with a high titre of anti A and/or anti-B iso-agglutinin of his serum. Many fatal cases of incompatible blood transfusion have occurred from thi cause.

c. Rhesus factor incompatibilities, particularly transfusion of Rh-positive blood int an *Rh-negative person, sensitized by previous* transfusion or pregnancy. Minor hæmolyti reactions resulting from rare varieties of Rhesus incompatibility (i.e. other than Rh-D) ar common; the more severe grades are comparatively rare.

d. Mixing bloods. On no account should blood of different groups be mixed outsid the body. Even though the bloods are individually compatible *with the recipient's serum* the mixture may prove incompatible.

e. If stored blood is more than 21 days old, effete erythrocytes are liable to be disrupte by the mild trauma of transfusion. The consequences are usually less severe than when a true hæmolytic reaction occurs. Heating stored blood above 100° F. (38.5° C.) can bring about a fatal hæmolytic reaction.

The symptoms provoked by transfusion of incompatible blood are abolished by *anæsthetics, and modified by morphine*. It is therefore doubly important that unless the patient's blood has been subjected to full laboratory ABO and Rhesus factor testing against the donor's blood, blood transfusion should not be performed while the patient is under an anæsthetic. In this connexion it should be remembered that auto-transfusion of blood

recently extravasated into the peritoneal or pleural cavity as a result of injury or in the case of the peritoneal cavity from a ruptured ectopic gestation, is free from these dangers.

Catastrophic Hæmolytic Reactions.—Nearly always appear very early in the transfusion.

Pemberton has well described the phenomena that he has observed in cases of incompatible blood transfusion The clinical picture of these reactions is typical. They occur early after the introduction of 50 100 ml of the blood the patient first complains of tingling pains shooting over the body a fullness in the head an oppressive feeling about the precordium and later excruciating pain localized in the lumbar region Slowly but imperceptibly the face becomes suffused a dark red to a cyanotic hue respirations become somewhat laboured and the pulse-rate at first slow becomes irregular The patient sometimes loses consciousness for a few minutes. Later the pulse may become very rapid or thready the skin becomes cold and clammy and the patient s condition is indeed grave Within from fifteen minutes to an hour a rigor occurs, followed by considerable pyrexia the temperature rising to 103 -105 F (39·4 -40·5 C). The patient may become delirious. The macroscopic appearance of hæmoglobinuria is almost constant. Jaundice occurs later

When a patient receives incompatible blood into his circulation death occasionally follows rapidly from hæmolytic shock. Much more usually after varying degrees of untoward symptoms followed by the passage of smoky red urine (hæmoglobinuria) oliguria, culminating in extreme instances in anuria sets in.

Histologically the renal tubules have been found blocked with precipitated blood pigments. In these circumstances it will be appreciated how much more readily previously damaged kidneys are overwhelmed.

Hæmoglobinuria usually appears within two hours of the transfusion, and is a signal that some degree of urinary suppression will follow Mild jaundice occurs in many cases, but it is not apparent for 24 hours after the onset of the reaction, and is not necessarily of grave significance.

Management and Treatment.—If the transfusion is stopped immediately serious untoward symptoms appear the eventual outlook is comparatively good. Too often blood transfusion is not stopped immediately a reaction commences. The following tragedy will serve to imprint indelibly the necessity for observing rigidly this fundamental injunction of blood transfusion :—

> A doctor s wife had a severe rigor while receiving a blood transfusion. Her husband came in, shut off the blood, and left the room to find the surgeon. An intern came in, turned on the blood and transfused the rest of the contents of the bottle Fifteen days later the patient died of anuria. (W J Kolff)

When shock is present, the next thing to do is to make arrangements to treat it effectively In the meantime in case the symptoms are due, at any rate in part, to allergy 0 5 ml. of adrenaline hydrochloride 1–1000 can be injected subcutaneously Although it has been the subject of some criticism there is everything to be gained and nothing to be lost, by rapidly alkalinizing the urine. For this purpose the dual injection intravenously of 10 ml. each of an isotonic solution of sodium lactate and a saturated solution of sodium bicarbonate (*Fig* 114) cannot be bettered. The reason for rendering the urine alkaline is to prevent the precipitation of crystals of acid hæmatin in the renal tubules. Once alkaline, the urine should be kept alkaline by giving sodium bicarbonate 5 gr (0·3 G) by mouth two-hourly for three days.

Fig 114 —It is an excellent practice to have these requirements right to hand at the commencement of every transfusion.

To return to the treatment of the shock if it is severe probably the best intravenous infusion for this particular variety of shock is dextrose-saline with noradrenaline (see p 77) Should noradrenaline not be available, dextran or plasma is gravitated fairly rapidly into a vein. As soon as convenient after the catastrophe a specimen of blood should be sent to the laboratory for an estimation of the free hæmoglobin in the serum usually there is considerable free hæmoglobin. The donor s and the patient s

blood should be *re-tested for ABO groups and Rh factor* and again cross-matched. bottle containing the remainder of the incompatible blood must be returned to the labo for investigation.

In every serious case, as soon as the patient s condition has improved even a and indubitably compatible blood or a suspension of concentrated red cells have obtained, one must be brave enough to recommence blood transfusion, for it is ol that in addition to the original need for blood transfusion which has not been me patient has lost by hæmolysis millions of erythrocytes. An exchange transfusion best course. 500 ml of blood is removed from a vein of one arm while 500 ml. of comp blood is transfused into a vein of the other arm. This can be continued until 5000 m been both removed and replaced The urine should be measured and charted.

From the commencement of the catastrophe the urinary output must be measure charted. A sample of each urination should be put in a test tube, and labelled wit date and hour of voiding It is best to place these test tubes in a rack, so that they c compared. Each specimen should be tested for its acidity and treatment directed t alkalinity

As soon as even serious oliguria, let alone anuria, becomes manifest (the patien probably need catheterization in order to settle this point) on no account should the inau tion of the treatment of renal anuria be delayed (see p. 500).

Less Severe Hæmolytic Reactions.—Hæmolysis can supervene more quietly hæmoglobinuria can follow transfusion without being preceded by hæmolytic shock. type is not rare after transfusion with preserved blood, and calls for a close watch o *urinary output. In these cases oliguria and anuria occasionally follow in a surrept* fashion.

2. SIMPLE FEBRILE REACTIONS

These are the commonest type of reaction. Although it is difficult to be certain aetiology of all these elevations of temperature, it has been proved that the majorit caused by the *introduction of pyrogens into the blood-stream. Pyrogens*, as their implies, are substances that produce heat, and they are for the most part, produc non-pathological bacterial growth in distilled water However pyrogenic agents ar necessarily bacterial some new rubber tubing contains a pyrogenic sulphur compo apparatus that has been imperfectly cleaned, and contains fragments of blood-clot previous transfusions, can be a potent source of febrile reactions. The foundation sto which their elimination rests is meticulous mechanical cleansing of all apparatus used in t fusion, followed by irrigating it with pyrogen-free distilled water and forthwith sterilizi by autoclaving There must also be scrupulous care in the preparation of anticoag solutions. *All these matters receive the closest attention in blood bank laboratories.*

Febrile reactions commonly occur when the transfusion is given rapidly under press probably fragments of clot are forced through the filter

Febrile reactions are more frequent between one and two hours after the commencen of transfusion than in its earlier stages. It is therefore wise to have the temperature t *half hourly during every transfusion*, and for at least two hours after it has been comple In the minor grades of pyrogenic reaction the patient experiences no discomfort, and reaction passes unnoticed unless these observations are made. With reactions of mode severity there is a complaint *of chilliness, followed by a feeling of being* too hot. M pyrogenic reactions are ushered in by a rigor The temperature rises to 103° F (39 5 C more. Accompanying these severe reactions there is often severe headache nause vomiting and restlessness. The pulse-rate is usually elevated, but *peripheral circula* collapse is uncommon. The duration of these phenomena varies with their severity m reactions commonly last about an hour those of a major grade may be prolonged for or three hours.

Treatment.—Only in the severe variety need the transfusion be terminated.[1] Asp 10 gr (0·6 G), followed by 5 gr four times a day for two or three days, is the only treatm required. Generally the temperature drops by crisis at other times by lysis over a pe of 24 hours or more The severity of pyrogenic reactions can be mitigated by keeping patient warm throughout the transfusion (Mollison).

[1] In cases where it is decided to continue the transfusion it is best to discard the bottle of bl and change the whole drip set.

3. ALLERGIC REACTION

These are the second most common type of r t d to denote the occurrence of urticaria and ... of the face ... blood transfusion. Usually the abnormality lies in the recipient ... followed the employment of the same donor on several ... who becomes hypersensitive to some protein in the donor ... nor with allergic asthma can convey that disease to the recipient ... If the recipient's history reveals sensitivity to proteins an intram... ml of the donor's serum should precede the transfusion. When ... tive an adequate amount of an antihistamine (e.g. Benadryl) can ... blood or the antihistamine can be given to the patient orally or intr... ute this precaution the patient exhibits allergic symptoms if ... lls instead of whole blood is given, frequently the reaction will not app...

An allergic reaction is usually evinced by ... urticarial weals which are apt to appear on the face, neck, and arms ... the eyelids and the lips. However weals may be extremely wid... become confluent so that the skin takes on a *peau d'orange* appearance. ... mucous membrane is involved, asthmatic coughing is produced ... pulmonary œdema follows.

Treatment for an allergic reaction is adrenaline hydrochloride 1–1000 0·5 ml. subcutaneously repeated if necessary. Gauze swabs soaked in ice-cold water should be placed on the eyes and lips if they are involved. For the skin elsewhere a 1 per cent solution of menthol in spirit can be applied to the involved regions with benefit.

4. REACTIONS FROM OVERTRANSFUSION (CIRCULATORY OVERLOADING)

The frequency of circulatory overloading has increased *pari passu* with the popularity of massive transfusions. Probably the most common cause of transfusion deaths, other than from incompatibility, is circulatory overload, culminating in pulmonary œdema. This complication is most likely to occur in cases of rapid transfusion given to elderly persons, those with cardiac or pulmonary disease (acute or chronic infection of the lungs) and thoracic injuries: such patients should not receive transfusion at a rate faster than 1 pint (568 ml.) in 4 hours.

Fig. 115.—Keeping watch for engorgement of the external jugular vein.

Diagnosis.—In every transfusion repeated watch must be kept on the cervical veins, and if fullness or engorgement of the external jugular vein becomes manifest (*Fig.* 115) with the patient lying propped up to 45° with the horizontal the transfusion must be stopped. If this precaution has been neglected, it should be known that the symptoms occur not early but late in the transfusion. Precordial pain, due to distension of the right auricle, is often a leading symptom. The next happening is a dry cough, followed by cyanosis and dyspnœa, culminating in voluminous expectoration of frothy sputum stained with blood; the stage of pulmonary œdema has now been reached.

Treatment.—If it has not been carried out already stop the transfusion. The patient, if recumbent, should be propped up. The emergency application of tourniquets to all four extremities, to obstruct the venous return, pools about 750 ml. of blood, and provides a rapid diagnostic and therapeutic measure. As soon as the symptoms are controlled, venesection should be performed, and at least 1 pint (568 ml.) of blood withdrawn. After this the tourniquets are released one by one. If pulmonary signs or cyanosis have developed, after $\frac{1}{4}$ gr morphine and $\frac{1}{150}-\frac{1}{100}$ gr of atropine have been injected subcutaneously oxygen therapy should be given but first empty the lungs by postural drainage if the sputum is copious. A cardiac stimulant, e.g., 1 mg., of digoxin intravenously is often helpful. Patients should be watched carefully for several hours, because recurrences are common. What so frequently happens is that the patient appears to be out of danger and then a few hours later pulmonary *œdema develops insidiously It is therefore always advisable to call in a physician in these cases.* Because in many instances pulmonary œdema is delayed, perhaps for as much as 24 hours, a fatality due to overtransfusion is often ascribed to some other cause.

5. REACTIONS DUE TO MASSIVE BLOOD REPLACEMENT

W S. Howland et al. found that 48 per cent of 180 patients to whom 5000 ml. or more of blood were administered during prolonged operations developed one or other of two major complications —

a. A hæmorrhagic diathesis, i.e., failure of the clotting mechanism.

b A cessation of cardiac function, either ventricular fibrillation or cardiac arrest.

One-third of patients who receive 10 or more pints of blood develop a hæmorrhagic diathesis.

It seems probable that citrate intoxication plays an important role at any rate in the development of the cardiac complications.

To control the hæmorrhagic tendency that follows the transfusion of large quantities of citrated blood, 10 ml. of a 10 per cent solution of calcium gluconate should be injected intravenously after each 1000 ml. of blood. In the ordinary use of blood transfusion citrate presents no problem in toxicity and calcium gluconate is not required.

INFECTED BLOOD

Contamination during Collection.—Freshly drawn blood is strongly bactericidal, consequently when blood is drawn into a sterile container the few organisms which possibly gain entrance to the blood from the skin have a poor chance of multiplying Culture studies indicate that infection occurs in 2–5 per cent but that the fresh blood nearly always kills the bacteria that gain entrance. Should a few survive provided the blood is chilled within 15 minutes, and kept at + 4 to + 6 C., they are unlikely to multiply and no harm will result if the blood is transfused within an hour of being taken from the refrigerator

Fig 110.—The "pilot bottle" provides blood for cross-matching

Bacteria already present in the Apparatus.—With modern methods of autoclaving the apparatus for blood collection, this source of infection, of which there were epidemics during the 1939–45 war has dropped to zero However bacteria which have been allowed to multiply in the acid citrate-dextrose solution, even if killed by sterilization, can cause serious, if not fatal, protein shock.

Bacteria introduced after Collection.—When stored blood becomes infected, infection usually occurs when the bottle is entered to obtain blood for cross-matching, or to remove plasma so that a concentrated red-cell suspension can be obtained. If the pilot bottle (*Fig* 110) is employed, the former danger is avoided. Even in sickness, the human body can destroy a few hundred living bacteria of almost any variety introduced into the blood stream Consequently even if stored blood is moderately contaminated often no harm results. On the other hand should an infected bottle of blood, after leaving the refrigerator be allowed to remain at room temperature for an hour or more organisms will multiply and may attain numbers sufficient to injure or kill the patient. In the case of pathogenic bacteria the danger of septicæmia is obvious. What is more difficult to appreciate is that non-pathogenic bacteria in sufficient numbers can kill by producing protein shock.

It should be noted that pathological organisms in blood stored at between +4 and +6 C. differ in behaviour *Str hæmolyticus* and *Staph. albus* diminish in numbers, whereas coliform bacilli often multiply ten fold in eight days. As has been pointed out on p 51 *there is an especial danger of contamination during the preparation of packed red cells by the open method.*

The Virus of Hepatitis.—There are two viruses that can be transmitted by blood or its products, and cause hepatitis. Infectious hepatitis becomes manifest 2–6 weeks and homologous serum hepatitis 2–3 months, after transfusion. While much has been said and written about virus hepatitis following infusion of plasma, a relative silence pervades regarding *the incidence of this disease following blood transfusion* In spite of the fact that no person known to have had hepatitis is accepted as a blood donor owing to the fact that many acquire the virus without developing recognizable symptoms, the incidence of hepatitis following blood transfusion remains at about 0·8 per cent making it many times higher than any other disease transmitted by transfusion.

The Recognition of an Infected Bottle of Blood or Packed Red Cells.—Unfortunately in a great number of instances there is no macroscopical means of telling if the contents of the bottle are infected A number of organisms cause hæmolysis, in which case the appearance of the blood in the bottle is well shown in *Fig* 81 A few cause an alteration in the clarity of the supernatant plasma which becomes opalescent. In a fatal case of septicæmia following the administration of infected packed red cells, Mollison noticed that the bottle smelled faintly of hydrogen sulphide as did an infected bottle of blood examined by Discombe

The risk of transfusing contaminated blood is an ever-present one This possibility can be minimized by —

1 Keeping blood at the correct refrigeration temperature until half-an-hour before use.
2. Limiting the period of storage to 21 days.
3. *Examining a methylene-blue-stained smear of the blood from the bottle immediately before transfusion in every case*

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CHAPTER 11

HÆMOPHILIA

BY ALLAN CLAIN M.B (Cape), F.R.C.S.(Eng)
Senior Surgical Registrar Royal Marsden Hospital, London

HÆMOPHILIA is a hæmorrhagic diathesis caused by deficiency in the blood plasma of a specific clotting factor known as antihæmophilic globulin (A.H.G). This factor is concerned with the generation of thromboplastin, which activates prothrombin to thrombin

Deficiency of A.H.G. is a hereditary sex linked recessive defect. Females transmit the condition, but escape the disease, all sufferers being males. Exceptions to this rule are almost unknown. A hæmorrhagic diathesis in a female is usually due to deficiency in the blood of substances other than A.H.G The incidence of hæmophilia is highest among Anglo-Saxon and Teutonic races , it occurs in Jews, but Latin races are apparently exempt. (The well-known affection of the Spanish Royal Family was transmitted from the Hapsburgs.)

Diagnosis.—Often the patient or his relatives will state that he is a bleeder or that males of the family suffer from the disease. This information should always be heeded, and before undertaking *any* surgical operation, e.g a dental extraction not only should the patient s coagulation time be ascertained but, when possible, the thromboplastin content of the blood must be determined. In the absence of a family history the following phenomena are suggestive of hæmophilia —

1 Excessive bleeding from slight trauma.

2. Bruising at the least provocation, particularly with hæmatoma formation.

3. Severe and repeated epistaxis.

4 Spontaneous bleeding from the gums.

5 Bleeding continuing more than 24 hours after tooth extraction or tonsillectomy is extremely suspicious.

6. Spontaneous hæmarthrosis, often recurrent. The knee-joint is particularly prone to be so affected.

After more obvious causes have been excluded, hæmophilia should be suspected in cases of gastro-intestinal hæmorrhage or hæmaturia in a young male.

Differential Diagnosis.—The clinician should eliminate the following —

1 *Purpura.*—The group of purpuras affect skin and mucous membranes only They do not give rise to hæmatomata. The loss of blood from mucous membranes is seldom serious

2. *Hereditary Hæmorrhagic Telangiectasia.*—In gastro-intestinal or urinary bleeding due to hereditary hæmorrhagic telangiectasia, telangiectatic patches, which can be obliterated by pressure, will be found in the skin and often on the lips.

Laboratory Confirmation of the Diagnosis.—Considerable delay in the coagulation time (normal 5–10 minutes) is most suggestive of hæmophilia. The bleeding time is normal. *It is, however important to note that reduction of the coagulation time as a result of blood* transfusion or plasma infusion does not necessarily indicate that the clotting mechanism i effective a special complex quantitative laboratory test for the presence of thromboplastin is necessary

GENERAL TREATMENT

The treatment of this group of conditions is still difficult, as the only effective method is by supplying the absent A.H.G This can be accomplished (*a*) by giving fresh blood or plasma (if prepared correctly) ; (*b*) by the administration of human, or better animal A.H.G [1] which, if available, is more effective. It should be noted that stored blood is valueless, except to replace lost red cells.

Hæmophilia.—During a bleeding episode, a transfusion of 1 pint (568 ml) of fresh blood or plasma is required every twelve hours, as A H G is rapidly lost in the body The blood or plasma should be given within three hours of donation, and *if stored plasma is used, it* should have been freeze-dried or frozen solid, as under these conditions it retains its anti-hæmophilic effect for many months.

[1] Maw Son & Sons Ltd., Aldersgate House Barnet, Herts.

In some cases with heavy blood loss in order to maintain hæmostatic efficiency as much as half the blood volume may have to be replaced every 24 hours.

The only effective route for blood (or plasma) is intravenously. Intramuscular administration is liable to lead to dangerous hæmatoma formation.

MacFarlane and his co-workers at Oxford have pioneered the uses of animal A.H.G., as the available human A.H.G. has a low potency. The former suffers from the disadvantage that it is antigenic and sensitivity reactions occur if its use is continued for more than 7–10 days. An extension of this time limit can be obtained by the consecutive use of different animal globulins.

At the present time only ox and pig preparations are being produced; their consecutive use permits 2–3 weeks for the performance of a surgical operation and the healing of the wound which should meet almost every requirement. It is of extreme practical importance therefore to avoid the use of other commercial coagulation agents that may sensitize the patient to animal A.H.G.

Related Conditions.—Clotting defects of the blood due to conditions other than hæmophilia will respond to the measures detailed above. In Christmas disease (hæmophilia B) which probably constitutes 10 per cent of all cases of coagulation defect the missing factor is more stable than the antihæmophilic factor and it is likely that the administration of preserved blood will suffice.

LOCAL TREATMENT

The object is to stop the hæmorrhage and promote rapid healing of the wound. If caustics or a cautery are applied bleeding will cease temporarily but will recommence when the slough separates. In extenuating circumstances this measure may be justifiable to gain time until more adequate treatment becomes available.

Local Applications.—Either Russell's viper venom or thrombin often proves effective for small abrasions and lacerations. Absorbable gauze[1] or gelfoam[2] provides a convenient way of applying these substances, as the gauze need not be removed after application and the clot is not disturbed. The gauze is soaked with the chosen solution and moderate pressure is exerted for five minutes.

Wounds.—Large vessels should be ligated securely with non-absorbable sutures. It is useless to stitch the wound margins tightly together to prevent oozing. Far more efficacious is to obtain hæmostasis with absorbable gauze, as detailed above, and crêpe bandage the part firmly but not tightly enough to impede the circulation.

The general hæmostatic measures detailed should be applied as soon as possible.

Dental Extractions.—When possible conservative dentistry is obviously desirable. If an extraction is essential, the following precautions must be taken:—

The patient should be admitted to hospital.

Two pints (1.134 L) of fresh blood should be given shortly before the operation.

General anæsthesia should be employed, because a local anæsthetic devitalizes the tissues.

The socket should be plugged lightly with absorbable gauze soaked in thrombin or Russell's viper venom.

Stitching the gums should be avoided as it is likely to be followed by a widespread hæmatoma.

An unprepared hæmophilic who bleeds after dental extractions is in a situation of great danger and the general measures detailed in this chapter should be instituted vigorously.

Epistaxis.—The bleeding point should be visualized with a nasal speculum, and a small pledget of absorbable gauze soaked in one of the hæmostatics mentioned applied with pressure for five minutes. Should this fail or if no special bleeding point can be found, the nostril should be packed in the usual manner (*see* p. 1066) with absorbable gauze. General measures should be instituted so that when the time comes for removal of the plug (24 hours) the coagulation defect will have been remedied temporarily.

Hæmatoma.—Incision will only lead to further bleeding. Masterly inactivity is the best policy but on occasions the surgeon's hand is forced, for example, when pressure by a hæmatoma in a limb is such that it endangers the arterial blood-supply. If needle aspiration and elevation fails, incision and evacuation of the liquid blood must be carried out, together with general measures to restore the coagulation mechanism.

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[1] Oxycel—Parke Davis & Co. Ltd.

[2] English equivalent—Sterispon. Allen & Hanburys Ltd., London, E.2.

A Retroperitoneal Hæmatoma may simulate an intra-abdominal catastrophe. If such a hæmatoma is found at laparotomy on a hæmophilic, it should be aspirated, not incised.

Cervical Hæmatoma—Threatened Asphyxia.—Endotracheal intubation or failing that, tracheostomy may be demanded urgently because of increasing respiratory obstruction due to hæmorrhage into the tissues of the neck or the floor of the mouth, occurring either spontaneously or following an operation in this region. With appropriate control of the hæmorrhage usually intubation can be discontinued after 48 hours. Tube feeding into the stomach may be required in similar circumstances.

Elective Surgery should if possible be avoided, e g an inguinal hernia should be treated with a truss.

Injections.—Unless bungled intravenous injections with a fine needle are unlikely to cause trouble but injections by the intramuscular route should be avoided owing to danger of hæmatoma formation.

Abscesses should be treated by repeated aspiration and specific antibiotic therapy rather than by incision.

Hæmarthrosis.—While rest to the joint in a Thomas's knee splint with skin traction applied in order to separate the joint surfaces are all that is necessary until the blood is absorbed progressive destructive arthritis is the usual aftermath of repeated attacks of hæmarthrosis.

An Emergency Operation should be performed only if there is no alternative course. Acute appendicitis, acute cholecystitis, and acute diverticulitis without perforation should, at any rate in the first instance, be treated by the Oschner-Sherren régime (*see* p 282) but with all in readiness to supply the missing coagulation factor should conservative treatment threaten to fail. Perforated peptic ulcer should be treated by the conservative methods (*see* p. 281).

Illustrative Cases.—

1 *W Walker's Case.*—

A male in his early forties, with a seven year history of repeated hæmatemesis (eleven in all) due to duodenal ulceration. On each occasion large blood transfusions up to 20 pints (12 L) were required. Twelve pints (7 L) of fresh blood were administered by exchange transfusion pre-operatively. Twenty hours later a difficult partial gastrectomy was performed.

Post-operatively bleeding occurred from the suture line and necessitated the transfusion of 39 pints (22 5 L) of blood (mostly fresh) and 38 pints (22 L) of fresh plasma over 27 days. The patient recovered.

It would probably have been wiser to have operated earlier than 20 hours after the pre-operative transfusion.

2. *Fraenkel and Honey's Case.*—

A 22 year-old hemophilic sustained accidental shot-gun wounds which caused a deep grazing injury to the left groin and several puncture wounds in the region of the left elbow Over the next 24 days, 17 pints (10 L) of stored and 3 pints (1 5 L) of fresh blood were transfused, but bleeding continued from unhealthy granulation tissue. Treatment was then started with ox A.H G It was found that the patient had been sensitized by the previous administration of a coagulation preparation from ox-platelets. After three days the ox A.H.G had to be discontinued, and pig A.H.G was hastily prepared. On the thirty fifth day after bleeding points had been tied and absorbable gauze dressings applied on several occasions, the pig A.H.G. became available, and thereafter serious bleeding stopped. Two days later skin-grafting was carried out and this was fairly successful. However on the fortieth day it was apparent that a rapidly expanding arterio-venous aneurysm at the left elbow was compressing the median nerve. It was decided that excision should be carried out urgently before the pig A.H.G could cause sensitivity reactions.

At operation there was no abnormal bleeding and the wound was closed around a small soft rubber drain. Healing occurred by first intention. On the fifty-fifth day pig A.H G was discontinued. During the period of treatment with ox A.H.G., 5 pints (3 L) of fresh blood 10 pints (6 L) of stored blood, and 3 pints (2 L) of fresh plasma were given. During the last phase of treatment with pig A.H.G blood transfusion was not required.

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CHAPTER VII

THE SHOCK SYNDROME

A subnormal temperature is the most constant and reliable sign of shock.
(Sir Zachary Cope).

SHOCK, more descriptively called peripheral circulatory failure can be defined as a state that ensues when the volume of circulating blood is insufficient to fill the blood vessels adequately

A few subscribe to the view that there is but one variety of shock Nevertheless there is much to be gained by recognizing two varieties—primary and secondary—a contention that is substantiated by the following table :—

Primary Shock	*Secondary Shock*
Comes on immediately	Delayed
Blood-volume normal	Reduced blood volume
Low blood-pressure ; sudden onset	Low blood pressure ; sometimes the fall is gradual
Pulse-rate usually slow	Pulse-rate nearly always rapid
Vasodilatation	Vasoconstriction
Often tends to pass off spontaneously	Without treatment, worsens

PRIMARY (NEUROGENIC) SHOCK

Primary shock develops immediately after a severe injury or a serious pathological catastrophe such as perforation of a peptic ulcer and not infrequently within a few minutes of the induction of spinal anaesthesia. Strong afferent impulses pass from the affected region to the central nervous system, and there cause disturbances in the functioning of centres controlling the circulation.

Psychogenic shock, due to fear or other strong emotions, is also not infrequent in nervous patients the expression I nearly died of fright is not necessarily hyperbolical (McNeill Love). The regularity with which fainting is combated by placing the head between the knees makes it probable that the main seat of vasodilatation in psychogenic shock lies in the splanchnic area. In the same category can be placed what is described as vasovagal collapse This has been observed most often in blood donors, about 3 per cent of whom, following the removal of 1 pint (568 ml) or less of blood exhibit signs of profound shock associated with an exceptionally slow pulse rate It has been shown that this type of collapse results from sudden dilatation of the arterioles.

Apart from psychogenic shock, primary shock is most frequently associated with severe wounds, major fractures, and crushing accidents. In the majority of instances the primary shock that occurs as a result of perforation of a peptic ulcer passes off quickly While, in many instances, primary shock tends to pass off spontaneously if it does not do so and remains untreated, it passes imperceptibly into secondary shock. On very rare occasions primary shock is the cause of sudden death.

DELAYED, OR SECONDARY SHOCK

Secondary shock (which is often known as oligæmic shock because a lowered blood volume is an essential accompaniment) is, if psychogenic shock be excluded more common than primary shock. It occurs usually 2 to 6 hours after the injury or operation, but occasionally it is delayed up to 12 hours, or even more. It comes on stealthily like a thief in the night, and, unlike primary shock shows no tendency to spontaneous recovery On the contrary unless treated early it becomes more profound. Consequently at the close of every relevant operation e.g resection of gut, the emergency surgeon should not

only consider the possibility of the development of delayed shock, but he should inaugurate concrete arrangements (if necessary in writing) for its detection and timely treatment.

Throughout this century the cause of delayed shock has been the subject of much patient research. Most workers in this field are convinced that the syndrome is due mainly to some noxious substance released from the traumatized area. Histamine, acetylcholine and ammonia are among the substances that have been blamed, but none has yet been proved beyond reasonable doubt to be responsible. That massive doses of endotoxin released from dead and dying bacteria killed by the appropriate antibiotic can produce shock is well proven, and is discussed under the heading of SEPTICAEMIA (p. 115). The theory that secondary shock is due to loss of potassium ions has not been substantiated.

Diagnosis.—When a moderate degree of early shock is present the patient says he feels ill. Thirst is a constant complaint, and is relieved only by restoration of the blood volume. Nausea and vomiting are frequently present. The patient is mentally alert, and usually lies quietly. His face is pale. Tested with the back of the hand, the extremities, and sometimes the nose, feel cool or cold. Veins are not prominent and the hands are often clammy. The volume of the pulse is poor, and except on rare occasions its rate is increased. It is true that, confronted with this emergency, the surgeon without a sphygmomanometer should be likened to a mariner without a compass; nevertheless, in the comparatively early stages of shock the blood pressure is not infrequently within normal limits. In all cases the cuff of the sphygmomanometer should be left in position and readings taken and recorded at very frequent intervals. It is necessary to know the normal average blood pressure in children; under 2 years of age blood pressure readings are unreliable.

Age	*Systolic Blood pressure* mm. Hg
2– 3 years	75– 90
4– 9 years	90– 95
9–14 years	95–105

The fact that the systolic blood-pressure does not fall appreciably until no less than 25 per cent of the circulating blood has been lost to the circulation should be indelibly imprinted on the tablets of one's memory. In an adult a fall of blood pressure to 90 mm. Hg is indicative that the peripheral vasoconstriction is no longer sufficient to compensate for the decreasing volume of circulating blood. *The temperature is below normal, usually in* the region of 98° F. (36.6° C.).

As shock becomes more advanced the face becomes white or ashen, and sometimes beads of perspiration stand out. The patient, by this time usually hollow-eyed with sunken cheeks, lies in a condition of exhaustion, and is aroused with some difficulty. In daylight, sometimes a cyanotic tinge can be perceived in the lips, ears, and nail-beds; sometimes *mottled cyanosis of the skin of the lower limbs can be seen, if looked for especially.* The body temperature becomes still lower (to below 98° F.); even the exhaled air may feel cool to the examiner's warm hand. The pulse is feeble and rapid (over 130). The blood pressure is often below 80 mm. Hg, and may be unrecordable. The output of urine is sharply reduced; in severe cases almost complete anuria supervenes. This is liable to be overlooked unless the patient is catheterized.

Living Pathology.—One thing is certain—there is decrease in the volume of circulating blood. As much as one-quarter or even a third of the total 9 pints (5 L.) of the average adult becomes lost to the circulation, mainly because a corresponding amount of blood fills the toneless capillary network of the body as if sucked up by a sponge. There is no mystery in the loss to the circulation of so great a volume of circulating blood when it is realized that the completely dilated capillaries of the muscles alone are capable of lodging this vast quantity of blood. The theory that there is general increased capillary permeability[1] is no longer valid; it has been disproved by experimental work (Fine). On the other hand, it is proved to the hilt that in cases of extensive local trauma transudation of serum occurs through the battered capillary walls in the vicinity of an injury. For instance, it is estimated that in a case of simple fracture of the femur as much as 2200 ml. of serum admixed with blood is extravasated locally (Ruscoe Clarke et al.).

[1] This does not apply to an excessive administration of an electrolytic solution, some of which passes into the tissue spaces even in normal subjects.

For the better understanding of the general mechanism of shock it is profitable to dwell for a few moments on the newer concept of the minute anatomy of the smallest blood vessels. As can be seen in *Fig.* 117 the capillaries are branches of a tiny direct arterio-venous channel well clothed with involuntary muscle. The entrance of each capillary is guarded by a precapillary sphincter. When as a result of vasoconstriction this closes, the blood in the capillaries stagnates. As the capillary tone diminishes the blood is sucked into the network from the venous end. This is what is meant by "pooling," and this is how blood is lost to the circulation in shock.

Laboratory Aids in Diagnosis.—While if facilities are available the opportunity should be taken to examine the blood, it must be stated categorically that the surgeon must rely almost entirely on the clinical findings to establish the diagnosis. It is believed widely, and stated in most surgical text-books, that hæmoconcentration is a fundamental characteristic of shock, without qualifying the statement. As is well known, hæmoconcentration is very frequently present in burns, and in this instance hæmatocrit readings are of great service (see p. 81). Hæmoconcentration is not present in primary shock, and is found comparatively infrequently in secondary shock. Indeed the only exceptions to this rule are the shock associated with crush injuries, peritonitis, and paralytic ileus. After an extensive inquiry into the subject Shoemaker is emphatic that hæmoconcentration plays no part in post-operative shock, the sole exception being the shock accompanying post-operative paralytic ileus.

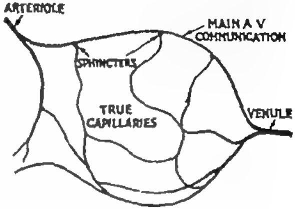

Fig. 117.—The minute anatomy of the capillary network. (*After Chambers and Zweifach.*)

In the comparatively few cases where hæmoconcentration is present, repeated examinations of the blood can prove a valuable guide to the amount of fluid that should be given. Of the four methods of recognizing hæmoconcentration—the hæmatocrit, specific gravity of the blood, hæmoglobin content, and the erythrocyte count—many research workers find that in shock *per se* the erythrocyte count is not only the simplest, but the most accurate.

Differential Diagnosis.—There is no difficulty in recognizing primary shock. On the other hand, the differential diagnosis between secondary shock (particularly post-operative shock) and internal hæmorrhage can be most disconcerting. A severely shocked patient lies quietly and is apathetic. Following a gross loss of blood the patient is restless, and suffers from air hunger. In early cases of internal hæmorrhage careful observation may reveal increasing pallor. In shock, if the thumb is pressed upon the skin and then removed suddenly, the area often remains blanched for a split second longer than normal. If intraperitoneal hæmorrhage is suspected, needling of the peritoneal cavity, as described on p. 302, is sometimes of signal service. Help can often be derived from repeated examinations of the blood, which should be carried out. Should there be some evidence of increasing anæmia the cause of the symptoms is due to internal hæmorrhage. Secondary shock has also to be distinguished from myocardial failure, including coronary infarction, especially in the elderly. In coronary *infarction* it must be admitted that true shock is present in 15 per cent of cases, but pain in the precordial area or the epigastrium is never absent. In myocarditis there is likely to be dyspnœa, the veins, instead of being collapsed, are well filled, and the heart becomes enlarged. If there is a possibility of the symptoms being due to a cardiac lesion, when possible the opinion of a physician should be sought, for to supplement the circulating fluid in myocardial failure is often to determine a fatal issue.

Irreversible Shock.—Until recently, shock that failed to respond to adequate supplementation of the circulating blood by colloid solutions administered intravenously was stated to be irreversible. This definition is no longer tenable because some patients in this desperate condition have recovered after the administration of noradrenaline or a retrograde arterial transfusion. Shock should only be pronounced irreversible when progressive anoxæmia due to diminishing cardiac output, grossly lowered blood-pressure, and reduced blood-volume has resulted in damage to the heart, brain, and adrenal glands, and every expedient to restore the blood-pressure has proved unavailing.

TREATMENT

Posture.—The value of lowering the patients by the head is seen clearly in the shock following spinal anaesthesia,[1] where it usually restores the initial fall in blood-pressure in a few minutes. The aid of gravity should be invoked as an emergency procedure and continued until the blood volume has been restored. As the position causes a certain degree of respiratory embarrassment, it should not be continued for longer than is considered absolutely necessary The tilt produced by blocking the feet of the bed 6 in. (15 cm. is usually sufficient to give the full benefit of the position, with little of its disadvantages.

Firm Bandaging of the Legs is strongly recommended. If available, Esmarch's bandages are the best for this purpose. Except as a first-aid measure where bandaging the arms is also advised the arms must be kept free, the one for recording the blood pressure and the other for the reception of fluid therapy Bandaging the legs at the end of a severe operation is also a valuable method of helping to prevent the onset of secondary shock. The bandages are removed only when a pulse of satisfactory volume has been maintained for several hours.

The Use of Sedation.—Particularly in the shock produced by war wounds, and traffic and kindred accidents, the value of morphine is unquestionable, but when it is given it should be used only to relieve pain and not as a routine procedure. Its beneficial effect is due to alleviation of factors contributing to primary shock. When given without indication, and especially if repeated, it serves only to depress the respiratory centres and possibly to aggravate an already existing tissue anoxaemia. Because of its respiratory depressant effects, patients suffering from shock due to injuries of the head or thorax should not receive morphine unless the pain is exceedingly severe. One-sixth or one-quarter grain is diluted to at least 1 ml. with sterile water and is injected intravenously over a period of not less than one minute. In patients suffering from shock subcutaneous or intramuscular injection of morphine must be avoided rigorously because the drug is often not absorbed when it is needed consequently repeated doses tend to accumulate and during the stage of recovery have been known to cause death from delayed absorption

An important part of the discomfort endured by the injured is due to fear and apprehension. This can be reduced significantly by administering a barbiturate 1–2 gr (60–120 mg) intravenously If after the injection the patient is reassured the need for morphine is often reduced considerably Maximum comfort can be obtained by the combined use of a small dose of morphine (¼ gr) and 1–2 gr of barbiturate both given intravenously

Emptying the Stomach.—If as is commonly the case the patient complains of nausea or vomiting an early opportunity should be taken to empty the stomach. Often at least some degree of dilatation of the stomach is present. If the amount of fluid recovered is considerable or bile-stained, the aspiration tube should be left *in situ* When the patient's blood pressure is very low this step should be postponed until he has received a litre of fluid intravenously Nevertheless, in the endeavour to restore the blood-pressure the fact that emptying a dilated stomach often brings about remarkable improvement in the general condition should not be forgotten (*see also* ACUTE DILATATION OF THE STOMACH, p 294).

Artificial Heating of the Patient should be avoided.—Until comparatively recently great emphasis was placed on the desirability of supplying warmth to the shocked patient. Consequently he was surrounded by hot water bottles, covered with an electric blanket, or placed in a heating cage. The urge to warm up the patient still lingers, especially among the nursing profession. It must be explained that the application of heat is most deleterious to the shocked patient. Firstly it causes the peripheral vasoconstriction of shock to give place to vasodilatation; *this not only deviates blood from vital structures* to the skin but it causes the disproportion between the volume of circulating blood and the capacity of the blood vessels to widen Secondly raising the temperature increases cellular metabolism, and consequently the oxygen requirement of the cells becomes greater Thirdly loss of fluid by the concomitant sweating increases dehydration. It is therefore of paramount importance to withhold all means of heating the patient's body artificially He should be nursed at room temperature covered by the same number of blankets[2] that are

[1] The method is applicable only when isotonic or light solutions have been employed. If shock occurs in the early stages of spinal anaesthesia and a heavy spinal anaesthetic has been administered, tilting the patient by the head is dangerous.

[2] The patient who feels cold needs blankets; the patient who is cold and does not feel it, is better left uncovered (Sir Heneage Ogilvie).

supplied to patients without shock. As the blood volume increases peripheral vasoconstriction decreases, and gradually the temperature will rise to normal or slightly above it.

N.B.: The rectal temperature is a more valuable guide than taking the temperature by other methods.

Oxygen Therapy (*see* Chapter LXI) has proved rather disappointing in the treatment of shock. Perhaps its greatest value in the treatment of shock is when the patient arrives heavily morphinized and consequently respiration is depressed. It should certainly be given when even a tinge of cyanosis can be detected in the nail beds or elsewhere. While in some instances, as a result of oxygen therapy the venous blood shows a substantial increase in oxygen content, usually no definite benefit accrues. Unless the patient is also suffering from such a condition as an injury to the thorax or pulmonary oedema when oxygen therapy is of the highest importance there is no substantial benefit from the inhalation of oxygen for such oxygen reaches only the lungs which obtain a satisfactory supply from the atmospheric air (20 per cent oxygen). In the majority of cases of shock it is not that the alveolar air is lacking in sufficient oxygen it is the deficient circulation that fails to carry sufficient oxygen from the lungs to the oxygen-hungry tissues.

Cortisone or ACTH is not now recommended. In those cases when it helped to raise the blood pressure it was found that in not a few after the drug was withdrawn shock reappeared suddenly after a variable period and sometimes proved fatal. On the other hand J. S. Lundy of the Mayo Clinic has found that 100 mg. of hydrocortisone added to 500 ml. of dextran is valuable, especially in combating the shock that sometimes accompanies a severe operation. Hydrocortisone appears to be free from dangerous effects after withdrawal.

Charts.—During the crisis there is no better method than an improvised half hourly or (for critical cases) quarter hourly record. Across the page are written the half or quarter hours, for example 2.30 3.0 3.30 p.m. Columns are provided for the temperature, pulse and blood pressure readings, in that order.

Fluid Therapy.—Restoration of the blood volume is the most effective single therapeutic measure for combating shock. While plasma or dextran as well as dextrose-saline solution, each have a prominent place in the accomplishment of this objective, in nearly all cases whole blood is the ideal fluid for this purpose. However unless the onset of shock has been anticipated and matched blood is in readiness, it takes time to procure correctly matched blood. The great advantage of blood substitutes is that they can be given with very little delay.

Warnings.—Here is the place to emphasize that unless it be Rh-negative type O blood, transfusion of whole blood should not follow immediately after plasma infusion as heterogenous agglutins introduced with the plasma are liable to cause severe reactions. Dextran is free from this objection. It should also be stated that unless the drops follow in such rapid succession as to be almost a flow the *drip method* of transfusion or infusion is comparatively ineffective in the *initial* treatment of shock. It is unfortunate that there is still lack of understanding of this cardinal principle.

Dextrose-saline Solution.—Admittedly comparatively ineffectual in restoring blood volume because electrolytic solutions diffuse from the blood-stream too quickly to be of lasting therapeutic value, dextrose-saline must not be despised. Frequently 1 litre given early will restore and maintain a significant increase in blood plasma volume for an hour while blood-grouping is being performed and plasma or dextran is being obtained. But there is another use for dextrose-saline solution that must never be lost sight of. If for one or other reason enough water and electrolytes to establish and maintain fluid balance and encourage an adequate urinary output cannot be taken by mouth, dextrose-saline solution should be given intravenously *in addition to* the colloid fluid therapy for shock.

Plasma.—Unlike electrolytic solutions, plasma neither passes rapidly into the tissue spaces nor is excreted by the kidneys. Plasma possesses an advantage over blood in that it can be administered at once. Grouping is unnecessary and as it never agglutinates red blood-corpuscles, no test of compatibility is consequently required. Plasma is therefore an excellent substitute for whole blood in the treatment of shock. In the treatment of burns it is often preferable to whole blood. In moderate exsanguination it is effective.

Disadvantages.—Following plasma administration, hepatitis occurs in at least 1.3 per cent of cases. If the plasma is derived from a pool of more than ten donors, the risk rises proportionately. Efforts to free the plasma of the hepatic virus have not come to complete fruition. Another factor to be taken into consideration is that it takes 2 pints

of blood to make 1 pint of plasma, and the supply of blood is less than the demand. This coupled with the fact that if plasma has been infused it is only completely safe to follow it immediately with Rh-negative type O blood—which is the type of blood that is in the shortest supply of all (because of the great demand)—is responsible for a waning of the popularity of plasma, while that of synthetic plasma volume expanders is increasing.

Administration.—Plasma is usually issued having been dried on the walls of the bottle (*Fig.* 118) and it can be kept almost indefinitely at room temperature. It is reconstituted by adding 400 ml. of sterile pyrogen-free distilled water and shaking vigorously for a few minutes. The result makes a normal-strength solution. Reconstituted dried plasma is opaque. If after ten minutes solution is not complete, the plasma must not be used. Plasma must never be used if the bottle is cracked or the cap is loose.

Fig. 118.—Dried plasma is reconstituted by filling up to the mark with pyrogen-free distilled water.

Plasma is sometimes supplied in a liquid form. Filtered liquid plasma should be crystal-clear and it must not be used if turbid. Liquid plasma should be stored away from the light in a cool dry cupboard. The expiry date of liquid plasma is set at 6 months.

In profound shock apparently moribund patients have been revived by rapidly administering as much as 3 pints (1·7 L) *of plasma in an hour or less. In order to carry out* massive infusions such as this, two veins must be cannulized or, better still, sternal puncture used for one avenue and a vein for another. The most rapid method of replenishing the circulation is by injection into the bone-marrow employing syringes (see p. 17).

Dextran 6 per cent in Normal Saline is pre-eminent among synthetic plasma volume expanders. Dextran is a complex polysaccharide which is composed entirely of dextrose-containing molecules of various sizes. When introduced intravenously, if the molecules are too large they produce untoward reactions. If they are too small they are excreted rapidly by the kidneys. The undesirable molecules are eliminated by various processes in the manufacture of dextran. Dextran shows little tendency to diffuse through the capillary walls. About 20 per cent is excreted in the urine within 6 hours, and about 30 per cent in 24 hours. Most of the remainder is catabolized slowly over a period of about a week. Thus at least 50 per cent of the solution is retained in the circulation for 24 hours. These desiderata are reached by the commercial products listed in the footnote. Dextraven[1] is supplied in bottles containing 1 pint (568 ml.)

Dangers and Untoward Reactions.—Barnard has seen a patient collapse shortly after the commencement of an infusion with 6 per cent dextran. He aspirated sludged blood from the vein, and later demonstrated that the recipient's erythrocytes were agglutinated immediately by dextran solution. The patient died. Therefore, no matter how urgent the necessity for replenishing the circulation, before administering dextran the precaution should be taken of taking a drop of the patient's blood and a drop of dextran, and placing them side by side on a white plate and mixing them. Only when there is no agglutination after waiting at least five minutes should dextran be administered. Comparatively minor adverse reactions occur in about 2 per cent of patients: these take the form of pyrexia, with or without generalized urticaria and dyspnoea with wheezing respirations, and they occur 30 minutes after commencing the infusion. If such reactions occur the infusion must be stopped at once and 0·5 ml. of adrenaline injected intramuscularly.

Advantages.—Dextran is virus-free and is stable indefinitely under all climatic conditions. No special storage precautions are required. If necessary, correctly matched blood can be transfused directly after the dextran, or admixed with it.

Administration.—In the average case 1 pint (568 ml.) should be administered fairly rapidly. This can be followed by a second bottle. Only in cases of very severe shock is it advisable to follow this with the contents of a third bottle; if further replenishment of the circulation is indicated, if possible whole blood should be given, because an excessive

[1] Dextraven (Benger Laboratories Ltd., Holmes Chapel, Cheshire.) Intradex (Glaxo Laboratories Ltd., Greenford, Middlesex.) Gentran (Baxter Laboratories Inc. Morton Grove, Illinois, U.S.A.).

amount of dextran will produce undesirable dilution of the plasma proteins, and when there has been an extravascular loss of blood a dangerous degree of hæmodilution.

Cross-matching of Blood in the Presence of Dextran.—It is generally stated that the presence of dextran in blood-serum causes such intense rouleaux formation that cross-matching becomes impossible. This is an exaggeration. It is, in fact, improbable that a small infusion of dextran will always interfere with cross-matching. Normally a sample of blood is obtained and sent to the laboratory before dextran is administered, but occasionally this is forgotten. In under half of these cases grouping and Rh typing are not interfered with; in the remainder (where 1000–1500 ml. of dextran has been given) the grouping can still be accomplished by an expert pathologist (N. A. Marston).

Blood Transfusion.—There is general agreement that blood substitutes are inferior to whole blood in the treatment of shock. If matched blood is available in the first instance and the shock is profound, as much as 2 pints (1.130 l.) can be given as fast as it can be made to gravitate into the vein. Accelerating the flow of blood by gravitation can be attained by raising the bottle of blood to the extreme height allowed by the attached tubing. Other methods of accelerating the flow are discussed on p. 49.

In a severely shocked patient, for every 600 ml. of blood administered a rise of 10 to 20 mm. Hg of the blood-pressure is to be expected. When the systolic blood-pressure reaches 85 mm. Hg the transfusion should be given more slowly. After the systolic blood-pressure has exceeded 100 mm. Hg it is well to give 500 ml. more blood.

When it is necessary to perform an operation as soon as the patient is in a fit state to undergo it, the aim should be to postpone the operation until the blood-pressure is normal. If this desideratum cannot be attained by intravenous transfusion, intra-arterial transfusion should be tried.

Retrograde Intra-arterial Transfusion (see p. 57).—The exact place of intra-arterial transfusion in the treatment of shock has yet to be defined, but in cases of profound shock if the patient has not responded satisfactorily to intravenous infusion, for reasons explained on p. 57, when correctly matched or Group O Rh negative blood arrives there is a strong case for giving it intra-arterially. Without hesitation intra-arterial transfusion can be recommended: (*a*) In patients who do not respond to the administration of 1000 ml. of whole blood intravenously and an urgent operation is necessary. (*b*) When a patient is *in extremis* from a combination of hæmorrhage and shock. In such cases arterial transfusion has been used to locate an otherwise occult bleeding artery. By increasing the arterial pressure, the source of the hæmorrhage has been brought into prominent view.

The Treatment of Severe Shock with Noradrenaline.[1]—Noradrenaline is a primary amine which has been demonstrated in mammalian blood, the adrenal medulla of cattle, and in phæochromocytoma—in the last it is the excess of this substance that gives rise to hypertension. Noradrenaline is advised especially in desperately shocked patients who fail to respond to the usual measures. It is important to diagnose the cause of the shock before noradrenaline is given, lest concealed hæmorrhage be aggravated by the drug. Noradrenaline is a powerful peripheral vasoconstricting agent that produces a rise in both the systolic and the diastolic pressures, provided, of course, that there is sufficient circulating blood to effect this change. It should never be given until after the more usual methods of treating shock have proved ineffectual. Noradrenaline must always be given intravenously, commencing with a very dilute solution; 4 ml. of noradrenaline is added to a 1000-ml. flask of dextrose-saline solution. To commence with, the rate of administration is 30 drops a minute, but a faster rate, up to 60 drops a minute, of a more concentrated solution, viz. up to 40 ml. per litre, has been used with success. As the blood-pressure rises the rate of the drip and the concentration of noradrenaline are reduced gradually to 7 drops a minute. Blood-pressure readings should be taken at 10-minute intervals throughout the day and night. If, as a result of slowing the rate of the drip, the blood-pressure again falls, the rate of the drip is accelerated. If a satisfactory blood-pressure is maintained over several hours, the drip is slowed gradually until it is considered safe to withdraw the cannula from the vein. A considerable number of cases of extensive necrosis around the site of infusion have followed the use of noradrenaline. As a preventive measure polythene tubing should be passed some distance into the vein, allowing more rapid dilution of the drug by the circulating blood.

[1] Levophed—Bayer Products Ltd., London.

B Hall's Case.—

After exploration of the common bile-duct for recurrent biliary calculi a woman of 55 developed severe post-operative shock. As the usual methods of treatment proved unavailing, noradrenaline was given in a continuous intravenous drip. For many days, directly the dose of noradrenaline was reduced considerably there was an immediate drop of the blood-pressure to 50–60 mm. Hg. On the seventeenth day in the endeavour to stop the drug 3000 ml. of plasma without noradrenaline was administered, and maintained the blood-pressure at 70–80 mm. Hg for several hours. Thereafter the noradrenaline was required in decreasing amounts for five days. The patient owed her life to the administration of noradrenaline for no less than twenty-two days. Extensive ulceration of the skin of the thigh occurred at the site where a polythene tube was introduced into the upper part of the saphenous vein.

THE TREATMENT OF PROFOUND SHOCK BY ARTIFICIAL HIBERNATION

Artificial hibernation is so called because the state produced by pharmacological suppression of the sympathetic nervous system resembles closely the oblivion, the low metabolism and the respiratory and cardiac rhythm of a hibernating animal. Of several drugs and combinations of drugs employed for this purpose, the following lytic cocktail is favoured by the majority of anæsthetists —

Chlorpromazine hydrochloride	50 mg	In 14 ml. of normal saline solution, given intravenously in divided doses.
Promethazine hydrochloride	50 mg	
Pethidine	100 mg	

These drugs create a partial blockage in the pathways to the vital centres, including the vasomotor centre. Thus the sum total of noxious stimuli causing and maintaining shock that reach the hypothalamus is, by reason of the action of these drugs, greatly reduced.

Provided artificial heating of the patient is disallowed, some degree of hypothermia results, metabolism is decreased, and the oxygen demands of the tissues are reduced correspondingly Another most important, effect is that the peripheral vasoconstriction of shock passes off permitting blood or blood substitutes to be gravitated into a vein or veins without hindrance.

Artificial hibernation is indicated particularly in those cases of profound shock that, without this treatment, would be classified as irreversible. The treatment has proved priceless when urgent operation is imperative, but the patient is in profound shock that otherwise cannot be remedied. Even patients who appear moribund from shock sometimes respond to this treatment. The details of a case reported by Shiela Kenny illustrate graphically the technique of inducing and maintaining artificial hibernation, and will serve as a guide to the application of this form of treatment in cases of ultra-severe shock.

A man, aged 60 was admitted to the Adelaide Hospital, Dublin, complaining of severe abdominal pain for 18 hours. On examination he was found to have an imperceptible pulse, an unrecordable blood-pressure, and board like abdominal rigidity He was very cold, pale and sweating Resuscitation with plasma and saline solution was commenced at once, and continued for six hours, but without any sign of improvement. A drip containing noradrenaline produced no rise in blood pressure.

A diagnosis of peritonitis following a perforated peptic ulcer of 18 hours duration was made and it was decided to produce a state of hibernation, and then to operate. In the operating theatre two transfusions of blood were administered simultaneously and 5 ml. of hibernation mixture was injected very slowly Shortly after the injection, venospasm being released, the blood gravitated into the veins more rapidly and within 5 minutes the pulse was recordable. At the end of 10 minutes, when 10 ml. of the mixture had been given the patient became warm and pink. A blood pressure of 50 mm. Hg was now recorded. The remaining 10 ml. of the mixture was given within a further 5 minutes the patient was intubated and moved on to the operating table. With blood transfusion proceeding, anæsthesia was supplemented by a 50 per cent mixture of N_2O and O_2. By this time the systolic blood-pressure had reached 85 mm. Hg For opening the peritoneum a dose of 3 mg of *d*-tubocurarine was necessary and adequate. Irregularity of the pulse caused some anxiety but digoxin 0·25 mg given intravenously produced obvious improvement. The blood-pressure was maintained at 60–90 mm. Hg with the help of a fast-running transfusion. A large perforation at the pylorus was sutured, and 10 pt. (5·7 L) of fluid was aspirated from the peritoneal cavity The abdomen was closed.

The patient was kept under mild hibernation by giving chlorpromazine hydrochloride 25 mg and promethazine hydrochloride 25 mg once a day for seven days. For the first 24 hours he was nursed without blankets, being covered by a sheet only In the first 48 hours urinary excretion was very low and caused anxiety but its return to normal on the third day suggested that lowered excretion was due to prolonged hypotension. Severe paralytic ileus developed on the second

post-operative day; gastric aspiration and fluid and electrolytic replacement were continued for nine days. During this period the blood pressure was maintained at 1*0 mm Hg by regulating the number of drops per minute of the fluid replacement The patient was discharged on the twentieth post-operative day in very good condition.

When operating upon a patient in whom artificial hibernation has been produced, the aim should be not to allow the temperature of the operating theatre to rise above 64·4 F (18·0° C.). Ideally at the end of the operation the patient's rectal temperature should be 97° F (36 1 C.)

When shock follows severe traumatic injury in a previously healthy individual the usual artificial hibernation can be augmented by refrigeration systemic and local brought about by placing rubber bags filled with broken ice on the precordium the abdomen, the inguinal and axillary regions, as well as along a limb if that be injured. The temperature is lowered, and consequently the metabolic rate is further decreased thus lessening the oxygen needs of the tissues.

General refrigeration which was used in the Korean campaign when severely wounded men had to be transported long distances, is not often necessary in civilian cases. If applied, it should be so modified as to cause a moderate drop in temperature only General refrigeration should never be commenced until after blocking of the autonomic system has taken full effect. A possible source of danger is that at low temperatures the clotting time and/or the bleeding time is inclined to be prolonged.

Artificial hibernation is contra indicated in thoracic cases as it is believed that it is dangerous to suppress both the circulation and the respiration in such cases.

Artificial hibernation greatly reduces the complexity of skilled nursing care, otherwise inseparable from desperately ill patients. In this connexion the especial danger of overhydration of patients who are kept unconscious or semiconscious for days must be proclaimed and reiterated To prevent this ever-present danger Huguenard advises that once fluid balance has been restored venoclysis should be replaced by hypodermoclysis with the addition of hyaluronidase If this precaution is taken it is unlikely that too much fluid will be administered.

ANAPHYLACTIC SHOCK

Anaphylactic shock is a rare but alarming accident. Typically it occurs during the intravenous injection, or shortly after intramuscular injection, of serum in a patient who has had serum of a similar origin more than ten days previously but it can occur after the injection of many substances, such as penicillin[1] or heparin, to which the patient has become sensitized. In addition to shock, the principal manifestation is spasmodic contracture of the smooth muscles of the bronchioles.

Prevention.—

1 Inquire whether the patient has had serum administered in any form previously also whether he suffers from asthma, hay fever urticaria, or eczema

2 When administering serum by any route, keep the patient under strict supervision and be on constant guard for untoward reactions. Always keep adrenaline and nikethamide (coramine) in readiness.

3. The accident can be avoided by a preliminary test for sensitiveness. A small trial dose (0·2 ml.) of undiluted serum is injected *subcutaneously* The patient is kept under observation for half an hour If no *general* symptoms develop the full dose can be given. (Laurent and Parish)

4 If the sensitivity test is positive or if it is necessary to give serum to a patient who has already received a dose more than a week previously the first dose should be 0·1 ml., and this should be doubled at half hour intervals for approximately six doses, when the remainder can be injected. Each dose should be combined with an injection of 0·3 ml of 1 1000 solution of adrenaline hydrochloride intramuscularly

5 In the absence of a positive reaction a good method of administering serum is to dilute it with a large volume of saline solution and to give the mixture intravenously by the continuous drip method; symptoms of anaphylaxis are then improbable

[1] At least 4 fatal cases of anaphylactic shock following the administration of penicillin have been reported.

Anaphylactic shock often comes on with dramatic suddenness. There is difficulty in breathing, followed, in the most acute forms by asphyxia and collapse. In other cases there are premonitory headaches and the patient complains of loss of vision. Gastro-intestinal symptoms are sometimes in evidence, and blood and mucus are passed per rectum. Distressing urticaria and swelling of the lips and other mucous membranes are usual. Oliguria and albuminuria sometimes complicate the syndrome.

Treatment.—The immediate treatment is to stop the injection, clear the airway and perform artificial respiration if necessary. Oxygen and CO_2, if at hand, should be administered. Inject adrenaline 0.5 ml. and nikethamide (coramine) 2 ml. both intramuscularly. Repeat the adrenaline if necessary. Should the blood pressure remain low treat the shock as detailed in this chapter.

Serum rashes accompanied by arthralgia and pyrexia are comparatively frequent after a large dose of any serum. Benadryl, a chemical preparation possessing potent antihistamine, has proved particularly valuable for these troublesome serum reactions: the average adult dose is one capsule (50 mg.) three or four times daily after meals.

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CHAPTER VIII

BURNS

By Douglas MacG. Jackson, M.D. (Camb.), F.R.C.S. (Eng.)
Surgeon, Medical Research Council Burns Unit, Birmingham Accident Hospital

Burns need emergency treatment, preferably in a special unit. If such a unit can be reached within several hours, a severely burned patient should be given its advantages, being transferred while plasma infusion is in progress.

The emergency treatment of burns is determined by three peculiar characteristics of the local lesion—an adherent slough of dead tissue, a zone of leaking capillaries, and a wound that although clean initially is particularly liable to bacterial contamination owing to the difficulty of closure. The primary aim is to remove the slough and close the open wound as soon as possible and without deformity; before this goal can be reached in an extensively burned patient the complications of shock and infection, which are the ones that kill, have to be overcome.

FIRST AID TREATMENT

A recent burn should be covered with a dry sterile or freshly laundered cloth at once to prevent bacterial contamination through contact with hands and clothes, and by air borne infection from those who are talking or coughing near the wound. For a serious burn immediate removal of the patient to hospital is very much more important than any other first-aid measures. A single effective dose of morphine may be given intravenously to adults if severe pain is present; in its absence this is unnecessary.

DIAGNOSIS

There are two important initial diagnoses to be made—the extent and depth of the burn. The *extent* of the burn can be calculated conveniently from Wallace's "rule of nine" diagram (*Fig.* 119); another useful measure in a scattered burn is the size of the front of the patient's outstretched hand and fingers, which is roughly 1 per cent of his body surface. If the area of the burn is more than 10 per cent of the body surface in a child, or more than 15 per cent in an adult, excluding erythema, the patient should be regarded as one who requires infusion with colloid to prevent oligæmic shock, and this treatment should be started at once. An early careful assessment of the total area burned is also helpful in gauging average plasma and blood requirements.

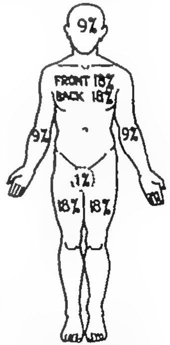

Fig. 119.—Rule of nine diagram for estimating area of burn.

The second diagnosis to be made is the *depth* of burning. This is important because definite and defined areas of full thickness skin loss are best treated by immediate excision and grafting. Some burns are clearly either superficial or very deep but in the large group which are of doubtful depth the pin prick test is useful. If the patient can appreciate the point of a sterile hypodermic needle as sharp when firmly pressed into the burned surface, the burn is one of partial-thickness skin loss and it will heal in three weeks without grafting. This type of burn should never be excised even if the surface is charred. If, however, the surface is analgesic on firm pressure with the needle, the burn may be deep partial skin loss or full thickness skin loss. Those without much experience should interpret analgesia of the burned area as signifying deep partial skin loss only. Sensitivity to pin-prick is of much greater significance than the surface appearance of the burn. Burns of the face, scalp, palms, and soles should never be excised on the evidence of the pin-prick test, and such factors as the history of the accident, sedation, age and temperament

of the patient, and the analgesic effect of some caustics such as carbolic must be weighed carefully. After full examination the depth of many burns is still in doubt and these must be treated conservatively.

LOCAL TREATMENT

If the burn is partial thickness skin-loss or of doubtful depth and the patient is not suffering from peripheral circulatory collapse a decision should be made to treat the burn by exposure or with a closed dressing. Both methods have a useful place and may be used at the same time on different parts of the same patient. *The method which is most easy to apply efficiently to the particular burn in the prevailing circumstances should be chosen.* To do this one must know the rationale of both methods.

Ninety per cent of recent burns are free of pathogenic organisms when they reach hospital. If a closed dressing is used it should be applied to prevent bacterial contamination and should be as bacteria proof as possible. The most satisfactory closed dressing at present

A B C

Fig. 120.—Electric flash burn of face treated by exposure. A, First day. Within a few hours of injury oedema completely closed the eyelids; this usually lasts 2–4 days. B, Third day. He was able to open his eyes for the first time. C, Twenty-seventh day. The burn had healed as partial-thickness skin-loss and without scarring.

consists of a *liberal application of stiff penicillin cream*[1] *spread on the burned surface*. On top of this is placed a layer of gauze, then a 1 in. (2.5-cm.) thick layer of dry cotton-wool extending liberally beyond the burn, followed by a crêpe bandage and sometimes plaster-of Paris to secure the dressing. *The value of such a dressing is beyond dispute in preventing* added infection, and as long as it remains dry and an efficient barrier it should be changed as infrequently as possible.

The exposure treatment allows bacterial colonisation in the burn slough but seeks to limit bacterial multiplication by drying the surface and keeping it cool and exposed to light. Splintage is sometimes required to prevent cracking of the crusts, and penicillin powder may be dusted on four hourly until the surface is dry.

In practice most burns can be treated in hospital by either method, but out patient treatment is much easier with burns (other than those of the face) dressed firmly. The face, buttocks, and perineum can usually be treated more efficiently by exposure (*Fig.* 120). Encircling burns of the trunk can be treated by exposure if the patient can be turned four hourly on a turning bed, but without this facility it is better to treat encircling burns by the closed method. *Nevertheless, hyperpyrexia* is a complication that should be watched for and if it occurs it calls for re-exposure. Temperature and humidity of the environment

[1] Formula of penicillin cream base: Ol. Ricini 23 per cent, Lanette Wax S.X. 14 per cent, Glycerin 10 per cent, Aq. ad 100. For method of preparation see Colebrook, L., *A New Approach to the Method of Treatment of Burns and Scalds*, 1950, 116. London: Fine Technical Publications.

will rule out closed dressings in some climates, and in some regions hæmolytic streptococcal infection appears to be less common than in Britain. Clinical trials in the Birmingham Burns Unit have shown that closed dressings with penicillin cream result in less added infection with pathogenic organisms than the exposure method, and deep burns appear to be ready for grafting sooner.

If the burn has been diagnosed as less than about 8 per cent of the body surface and definitely full thickness skin loss, primary treatment should be excision and grafting. This should be done with a tourniquet in place when possible and the zone of red fat should be removed with the dead skin (*Fig* 121). More extensive excisions are probably unwise as an emergency measure outside special units, since hæmorrhage is liable to be unexpectedly great.

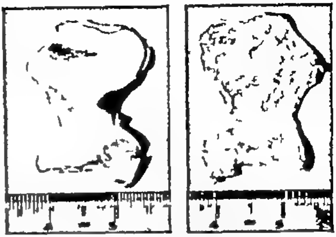

Fig 121.—Excised molten metal burn of foot. With the limb exsanguinated the red fat which has no circulation becomes obvious. This initial excision has been inadequate in the deepest central zone

If the patient is a "shock case" exposure or the simplest cover with sterile towels and crêpe bandages is all that is indicated until shock is well under control.

TREATMENT[1] OF SHOCK

A recent extensive burn in an adult may lose as much as half a litre of plasma an hour: plasma infusion is therefore *urgent*. Yet because the loss is slow compared with that of serious hæmorrhage, the blood pressure usually remains normal until the blood volume is so reduced that clinical shock, as shown by pallor, thirst, restlessness, and coldness of the extremities, becomes apparent. A burned patient received soon after injury should never be allowed to reach this stage.

The aim of transfusion is to replace the exudate and red cells lost from the circulation. It has sometimes been assumed that the exudate is akin to half-strength plasma as regards proteins, but the protein content of blister fluid and of lymph returning from a burned limb frequently agrees closely with that of reconstituted plasma (about 5·0 G. per cent). Plasma therefore seems to be the colloid replacement fluid of choice, though 6 per cent dextran in saline is a good substitute. Intravenous saline is unsuitable since it is rapidly lost into unburned tissues and increases the risk of pulmonary œdema. Much water may also be harmful by diluting the body electrolytes and causing water intoxication. For practical purposes one may regard plasma as the correct fluid to replace exudate, whole blood to replace red cells, and water or 5 per cent glucose in water to replace the daily water loss of the lungs, sweat, and urine. Reconstituted plasma contains more sodium and potassium than normal plasma—about 165 mEq./l. of sodium (normal 137–148 mEq./l.) and 13 m.Eq./l. of potassium (normal 3·9–5·0 mEq./l.).

THE RATE AND AMOUNT OF PLASMA INFUSION

1. **Using Repeated Red-cell Volume and Hæmatocrit Estimations as a Guide.**—Oligæmia is most effectively controlled by repeated red-cell volume and hæmatocrit estimations, and continuous replacement of the measured loss of plasma and red cells. At the present time, however, this method requires facilities found only in a few specialized units, so that alternative methods are called for which require little or no equipment or special experience.

2. **Using Repeated Hæmatocrit Estimations and Expected Red-cell Loss as a Guide.**—Given a small centrifuge in the clinical room next to the ward, capillary hæmatocrits can be done quickly and frequently without laboratory staff or special skill (*Fig.* 122).

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[1] Oxygen is not indicated for the stagnant anoxia of burns shock unless there is a pulmonary or a cardiac lesion as well. Cortisone similarly is without benefit.

First, the patient's normal blood volume, red-cell volume, and venous hæmatocrit (this is the same as the capillary hæmatocrit from a warm ear or finger) should be noted for his age, height, or weight from a table of average normal values (*Fig.* 123).

Then the actual capillary or venous hæmatocrit of the patient is measured.

With burns involving less than 20 per cent of the body surface the red-cell loss averages less than 10 per cent of the patient's cells so that blood transfusion *is unnecessary and an oligæmia* greater than 10 per cent is unlikely when the hæmatocrit is normal. If in such a burn we assume that no red cells have been lost in the two hours since injury, the volume of plasma lost as exudate and œdema can be calculated from the initial hæmatocrit and the average red-cell volume. If we suppose this total loss is 400 ml., the rate of plasma loss will be 200 ml. *an hour*. In the next hour, therefore (the first hour of infusion), the hæmatocrit and blood volume will be restored to the average normal by 600 ml. of plasma. After this, the plasma rate is only reduced as the hourly and eventually four-hourly hæmatocrit falls below the average normal figure. The infusion should continue *for 24–48 hours, being stopped* when the hæmatocrits show that it is no longer required.

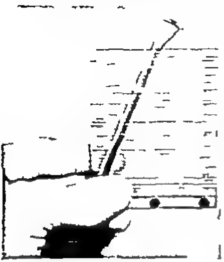


Fig. 122.—Hæmatocrit tube after centrifuging. The proportion of red cells to total sample of blood is the venous or capillary hæmatocrit, uncorrected for trapped plasma between the cells. To obtain the true venous or capillary hæmatocrit corrected for trapped plasma, subtract 2 per cent if the centrifuge hæmatocrit is 20–29 per cent, 3 per cent if the centrifuge hæmatocrit is 30–49 per cent; 4 per cent if the centrifuge hæmatocrit is 50–60 per cent.

Even in such cases infusion of plasma should never be guided entirely by the hæmatocrit. The clinical condition of the patient is of the greatest importance. Pallor, thirst, restlessness, cyanosis, and coldness of the nose and limb extremities are all signs of oligæmia, and so also is an hourly output of less than 20 ml. of urine in a child and 25 ml. in an adult. These signs call for an increased rate of plasma infusion.

With burns of more than 20 per cent full-thickness skin loss, and especially if more than 40 per cent total area, considerable red-cell loss should be expected and watched for, though it does not always occur; when it does so it is unpredictable both in time and degree, and this is why the ideal treatment involves 12-hourly red-cell volume estimations. The *greatest loss in the first 12 hours after injury is rarely more than 20 per cent of the patient's* red-cell volume. This amount should therefore be given in the first 12 hours and the hæmatocrit kept around normal or 10 per cent above normal. *A further 20 per cent of* the red-cell volume should be given in the next 36 hours if indicated by signs of oligæmia or further red-cell loss (e.g., hæmoglobinuria, an unexpected fall in the hæmatocrit, hæmatemesis, or melæna); it is usually required if the burn is more than 40 per cent total area and largely deep. In some cases as much as 30–70 per cent of the normal red-cell volume may be lost by 48 hours; this includes both patient's and transfused cells.

Oral fluids should be sufficient to cover loss by urine, sweat, and respiration in this régime. It is sufficient for an adult to pass 600 ml. of concentrated urine a day, so that oral intake is limited to 90–125 ml. an hour, or 2–3 litres a day. Children under 5 years are limited to 60 ml. an hour (about 1·5 l. daily). If vomiting should make oral administration impossible the same volume of 5 per cent glucose in water should be added to the hourly intravenous intake.

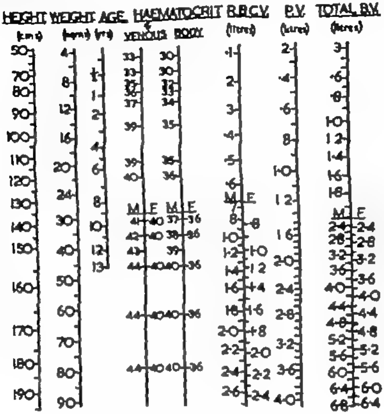
A 4-year-old girl was alone at home when she received burns of the trunk and thighs as a result of putting paper in the fire. The extent of the burns was 25 per cent, 23 per cent of the body surface being full-thickness skin-loss. On admission she had acute bronchitis and a temperature of 103° F. (Her height was 97 cm. and weight 14 kg. Accepted average normals from this data were: blood volume 1·0 l., red-cell volume 330 ml., body hæmatocrit 33 per cent; venous hæmatocrit 39 per cent.)

Two hours after injury she was thirsty, her extremities were warm, and her venous hæmatocrit was 40 per cent. Plasma infusion was maintained for two hours, followed during the next four hours by transfusion of 400 ml. of blood, which was equivalent to nearly 40 per cent of the red-cell volume.

Assuming that none of her red cells had been destroyed, this treatment would have given her a red-cell volume of 460 ml. (the hæmatocrit of bottled blood being usually 33 per cent); and when

her blood volume was normal her body hæmatocrit would be 48 per cent and her corrected venous hæmatocrit 53 per cent

Usually the hæmatocrit of such a burned child would have been kept somewhat below the new expected normal to allow for a 10 per cent loss of her red cells in this case at 48 per cent. But



* VENOUS HAEMATOCRIT CORRECTED FOR TRAPPED PLASMA (35 minutes 3000 r.p.m.)

Fig. 123.—Table of average normal values. The values for the venous hæmatocrit have been corrected for trapped plasma (see *Fig.* 122). The body hæmatocrit is the proportion of the body red-cell volume to total blood volume. In practice the body hæmatocrit may be calculated by multiplying the corrected venous hæmatocrit by 0·9.

this child's extremities remained cold and there was oliguria with a venous hæmatocrit at 48 per cent and it was concluded that she might have more red-cell destruction than the average 10 per cent. Accordingly the hæmatocrit was maintained around 43 per cent (*Fig.* 124).

Vomiting was frequent at first though not severe. It ceased as soon as the ration of 60 ml. of water an hour was given intravenously. Plasma was stopped at 28 hours, after 1520 ml. had been given. One specimen of urine at 44 hours was bloodstained; the child had not been catheterized. Subsequently progress was uneventful, the patient being discharged to convalescence after two operations during 56 days in hospital.

This case history illustrates treatment of a 23 per cent full thickness skin loss burn using the venous hæmatocrit and average red-cell destruction figures as a guide modified by additional clinical signs such as cold extremities and oliguria.

3. Using a Formula for Average Requirements as a Guide.—Several formulæ have been devised as an initial guide to the rate and amount of plasma therapy. Their greatest use is in an emergency or for mass casualties, and then their value lies in their simplicity. All the formulæ are based on the principle that the plasma requirements are proportional to the extent of the burn. This is only true for the average case. Although the formulæ conform with the *average* requirements and are a useful guide they may occasionally diverge as much as 100 per cent or more from the patient's individual needs as gauged by the clinical condition, blood volume studies, or serial hæmatocrits. For this reason each patient's treatment should be based upon his own hour-to-hour clinical condition as with all the previous methods. Two formulæ are described below:—

a. Over 10 years of age 1–1½ litres of plasma are needed for every 10 per cent of the body surface burned, excluding erythema. Under 10 years an amount of plasma equal to the

normal plasma volume of the patient is required for every 15 per cent of the body surface burned excluding erythema. The amounts calculated from these formulæ are the total plasma requirement, a half of which should be given in the first 8 hours and the other half over the succeeding 16 or 24 hours. No arbitrary maximum dosage is suggested. The indications for blood (which is not *included in the formulæ) and the* management of oral fluids are the same as described above for use with the hæmatocrit method. Saline is not given intravenously nor is 5 per cent glucose in water except as a substitute for oral fluids if the patient cannot take fluid by mouth

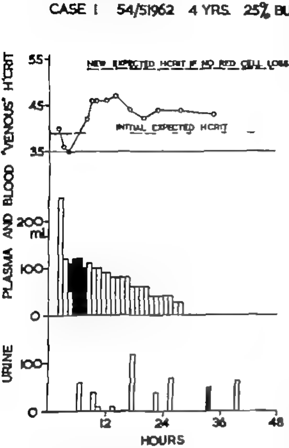


Fig. 124.—Progress chart of shock treatment using serial hæmatocrits and expected blood loss as a guide

b An alternative formula described by Wallace based on a similar one by Cope and Moore states that in adults 110 ml each of plasma and saline *should be given in the first 48 hours for* every 1 per cent of body surface burned the fluid being divided into equal quantities for the periods 0–8 8–24 and 24–48 hours after burning For children the amount is proportionately less by weight The amount calculated for a 30 per cent burn is only reluctantly exceeded if the burn is larger than this. In addition water or glucose drinks are given by mouth to cover normal metabolic requirements (1 to 10 years—*1500 ml. 10 to 16 years—2000 ml.* adults—3000 ml.). For deep burns and all burns over 25 per cent the composition of the total 48-hour volume is changed to a half as blood, a quarter as plasma, and a quarter as saline—one half of this being given in the first 8 hours after injury *It cannot be repeated too often that the strongest supporters of the formula method recognize it only as an initial guide* the surgeon must be prepared to modify resuscitation from hour to hour by checking the urinary output and the clinical response to treatment at the bedside

TREATMENT OF INFECTION

The myth that a recent burn is "an infected open wound caused by heat" still lingers on and doctors can still be found who consider their hands cleaner bacteriologically than a recently inflicted burn. The truth is that nine out of ten recent burns admitted to a Casualty Department are free from the pathogenic organisms which are usually found on the hands of medical attendants. In spite of the fact that the cause of death in the majority of fatal cases which have a chance of survival is some type of infection, it is difficult to impress doctors and nurses sufficiently with its importance One act of failure to wash one's hands or use sterile instruments, or one cough without a mask when dealing with a badly burned patient may put group A hæmolytic streptococci or *Ps. aeruginosa* on the burn and determine a fatal outcome

Prophylaxis.—Measures to *prevent* infection include immediate clean first-aid cover for the burn examination of the lesion at all times by no-touch technique and wearing a mask and the separation of recent clean burns from infected wounds while waiting for and during dressings. If a dressing is applied it should be as bacteria proof as possible as described above and it should be changed as infrequently as possible as long as it remains efficient. Filtered air at positive pressure in the dressing room has been shown to be definitely beneficial, but the tendency to give up all anti-infection measures in its absence is as unwarranted in

dealing with burns as with compound fractures. Finally primary excision and grafting is an excellent anti-infection measure since the infection risk ceases only when the wound is healed.

The value of penicillin cream (1000 units/G.) in routine dressings has been established by clinical trial. Added infection with hæmolytic streptococci occurred in 2 per cent of treated cases, in contrast to 38 per cent of control cases—a degree of protection not to be wantonly cast aside. Serious skin sensitivity to penicillin when used in this way is a negligible risk.

These measures are directed at minimizing the bacterial colonization of the burn which in turn lessens the frequency of bacterial invasion of the patient and failure of skin-grafting due to infection. In the management of burns, as in general operating theatre technique the secret of success is not any one factor but strict daily attention to the exclusion of every possible source of infection.

Antibiotic Therapy.—Prophylactic measures may be completely successful with burns of limbs, but are usually less effective for extensive burns with much exudate and those involving the face and buttocks. Bacteriological swabs should be taken from each burn site at each dressing, and daily from large exposed areas. Knowledge of the nature of the organisms present should be available to the surgeon by the following day.

If group A β hæmolytic streptococci are present systemic terramycin, tetracycline aureomycin, or erythromycin will usually get rid of them within five to seven days. If toxic symptoms such as vomiting, diarrhœa, or colic make these drugs inadvisable stronger penicillin cream (10,000 units/G.) applied three times (i.e. on alternate days for 6 days) should be substituted: this entails more work than systemic chemotherapy but is a most valuable second weapon. Systemic penicillin is quite ineffective as it will almost certainly be destroyed by penicillinase-producing staphylococci at the site of the burn. During exposure treatment dusting the burn with penicillin powder[1] (10 000 units/G.) is probably beneficial: its effectiveness is presumed by analogy with the proven benefit of penicillin cream.

Ps. aeruginosa and coliform bacilli are the next most important organisms causing failure of skin-grafting and they are the cause of the most serious septicæmias and pneumonias. Colonization of the burn surface with these organisms is greatly reduced by the addition of 0·1 per cent of polymyxin to the penicillin cream and its application on alternate days is a valuable therapeutic measure. Bacterial invasion with these organisms is best treated with chloramphenicol and intramuscular polymyxin.

NUTRITION

A patient with a large burn has an increased metabolic rate and a protein leak sometimes amounting to a litre of exudate a day. An ordinary full diet is inadequate in these conditions and supplementary feeding should be given, if necessary by a polythene or Ryle's tube through the nose into the stomach. A useful mixture is—milk 18 oz. (511 ml.) two eggs, dextrin-maltose 1½ oz. (42 G.), and sugar 1 oz. (28 G.). This provides 780 calories per pint (568 ml.) and the usual requirement is 3–4 pints (about 2 l.) a day.

ELECTROLYTE CONTROL

Provided urinary output is adequate in volume and concentration, and normal feeding is started on the second day, the body can usually be left to control the electrolyte imbalance unaided. If however renal output or food intake is disordered, blood chemistry and urine examinations are imperative to diagnose serious disorders which may become fatal. It is common for the patient to pass through a stage of low serum-sodium levels (125–130 mEq./l.) and it is doubtful if this is of any clinical significance. A low serum potassium is also not uncommon and can be corrected by adding potassium chloride to the diet or tube feed. If acute tubular necrosis should develop the serum-potassium level must be kept down by every available measure[2] as hyperpotassæmia is the cause of death in this condition.

Respiratory Tract Burns.—Tracheal and pulmonary damage is usually the result of involvement in a conflagration, but œdema of the glottis may follow drinking very hot

[1] Penicillin—sulphonamide powder should not be used: the absorption of sulphonamide is liable to prove toxic.

[2] *See* Treatment by Ion-Exchange Resins, p. 605.

liquids. The former calls for immediate tracheotomy the administration of oxygen, and removal of the frothy exudate by postural drainage and frequent aspiration. For respiratory obstruction due to drinking hot liquids tracheotomy should be carried out as a planned operation as soon as obstruction is clearly increasing Tracheotomy is *not* necessary for burns of the skin of the neck. The gross œdema in these cases cannot reach the larynx, and elevation to the sitting posture soon causes the œdema to spread downwards over the trunk.

SPECIAL TYPES OF BURN

Electric Contact Burns.—*Multiple small areas on the hands* should be excised at once under a tourniquet with all red fat, and the defects covered with skin-grafts. As these burns are sometimes deeper than expected, flap cover for exposed tendons should be planned beforehand for use if necessary A coagulated limb should be watched for two or three days before amputation It is easier to be sure of the limits of necrosis after this period.

Caustic Burns.—The immediate first-aid treatment is copious washing with water After this a wet compress with a buffer solution will further neutralize the caustic which is often of unknown composition. (Formula of buffer solution Monobasic potassium phosphate (KH_2PO_4) 70 G dibasic sodium phosphate (Na_2HPO_4 $12H_2O$) 180 G., in 850 ml of water This makes 1 litre of solution.) The solution is non-irritant and may be used in the eyes.

SPECIAL SITES OF DEEP BURNING

Eyelids should be grafted 2–3 weeks after injury with the rest of the face. Inability *to close the lids over the cornea before this time is a rare but dangerous condition calling* for expert plastic surgery

Hands.—Full thickness skin loss areas on the hands share priority with the face for early grafting To get good results it is important to have them grafted and healed by four weeks after injury

A

B

Fig 123.—A useful splint to immobilise the hand in the optimum position is a firm crêpe bandage over wool with a pad in the palm. Serious burns of the hand should be dressed with penicillin cream and gauze with pieces of gauze between the fingers to keep them separated.

In a patient with very extensive burns the treatment of deeply burned hands must take second place to the life-saving measures of reducing the size of the open wound. The most important step in this delayed treatment of the hands is their maintenance in the optimum position with the wrist dorsiflexed and the metacarpophalangeal joints at a right angle The position is kept most easily with the hand grasping a pad of wool in a boxing glove type of dressing (*Fig* 123).

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CHAPTER IX

IMPENDING DEATH UNDER ANÆSTHESIA

EVERY surgeon is bound to encounter this ordeal. The expectation of death under an anæsthetic is 1 per 1000 when calculated on 230 000 cases from five teaching hospitals on three continents (Waters and Gillespie) Most emergency surgeons are removed from the facilities of a teaching hospital their patients are often very ill and must be prepared for operation hastily For these reasons an emergency surgeon comes face to face with impending death under anæsthesia (which equals torrential hæmorrhage, as the most urgent of all emergencies) relatively often.

Of 1200 cases of cardiac arrest collected by Stephenson et al. the highest incidence (over 20 per cent) occurred in patients under the age of 10 years. The reason given for this remarkable preponderance is that during infancy and early childhood reflexes are highly

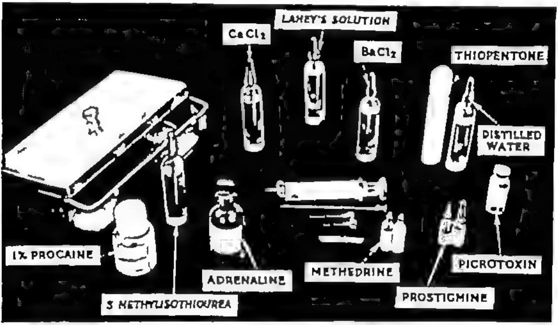

Fig 128.—Cardiac emergency outfit

sensitive. Another important fact which merits attention is that 14 per cent of cases of cardiac arrest occur in patients anæsthetized outside the operating theatre or its immediate environs i e during anæsthetics given in bed or in the dental chair

My introduction to this important subject was when as a student, I was called upon to help in an unavailing attempt to revive a girl who had collapsed under nitrous-oxide anæsthesia. Since that time I have often reflected how profitable it would be to have organized drill to prepare us for these cases. Unfortunately with an operating theatre staff changing constantly this is seldom practical It is, however essential for the surgeon to have a preconceived plan of action imprinted on the tablets of his memory so that he can put it into action immediately the calamity occurs.

PREPAREDNESS

It is unwise to procrastinate setting aside enough time to get in readiness three sterile packages containing (*a*) the drugs, (*b*) the instruments, (*c*) a defibrillator against the day they will be required, and to keep them in a readily accessible specified place in the operating theatre

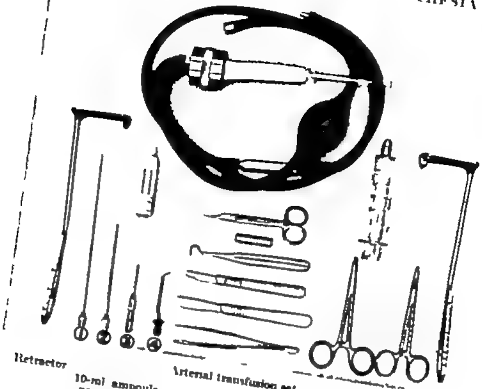

Fig 127 —Equipment for cardiac resuscitation

a. A jar sealed with adhesive tape containing a syringe and needles and the drugs that are shown in *Fig* 126. This is labelled Cardiac Emergency Outfit

b Although it is true that in order to commence cardiac massage a scalpel is the only instrument required, it is far better to have in a sterile package all the instruments and other equipment that are likely to be required for cardiac resuscitation (*Fig* 127)

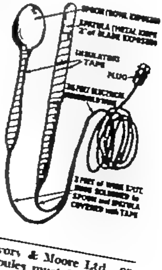

Fig. 128 —The construction of a simple defibrillator (*After Max Thorek*)

c Comparatively few operating theatres are provided with an electric defibrillator of which there are several patterns. Nevertheless one can be constructed with the help of an electrician at a very low cost (*Fig* 128) Faced with ventricular fibrillation, without a defibrillator one is usually powerless.

Ten-ml. ampoules of procaine-adrenaline solution are put up by Savory & Moore Ltd., 60 Welbeck Street London, W 1 The adrenaline deteriorates, and the ampoules must be renewed after three months.

CHAPTER IX

IMPENDING DEATH UNDER ANÆSTHESIA

EVERY surgeon is bound to encounter this ordeal. The expectation of death under an anæsthetic is 1 per 1000 when calculated on 230,000 cases from five teaching hospitals on three continents (Waters and Gillespie). Most emergency surgeons are removed from the facilities of a teaching hospital their patients are often very ill and must be prepared for operation hastily For these reasons an emergency surgeon comes face to face with impending death under anæsthesia (which equals torrential hæmorrhage, as the most urgent of all emergencies) relatively often.

Of 1200 cases of cardiac arrest collected by Stephenson et al. the highest incidence (over 20 per cent) occurred in patients under the age of 10 years. The reason given for this remarkable preponderance is that during infancy and early childhood reflexes are highly

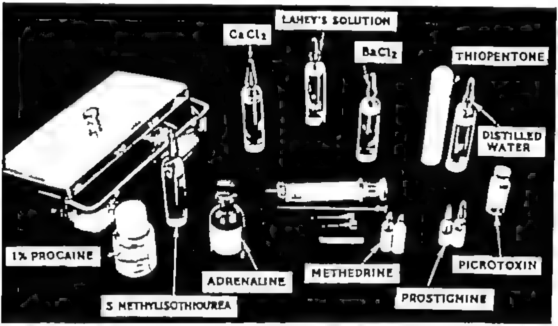

Fig 128 —Cardiac emergency outfit

sensitive Another important fact which merits attention is that 14 per cent of cases of cardiac arrest occur in patients anæsthetized outside the operating theatre or its immediate environs, i e, during anæsthetics given in bed or in the dental chair

My introduction to this important subject was when, as a student, I was called upon to help in an unavailing attempt to revive a girl who had collapsed under nitrous-oxide anæsthesia. Since that time I have often reflected how profitable it would be to have organized drill to prepare us for these cases. Unfortunately with an operating theatre staff changing constantly this is seldom practical It is, however essential for the surgeon to have a preconceived plan of action imprinted on the tablets of his memory so that he can put it into action immediately the calamity occurs.

PREPAREDNESS

It is unwise to procrastinate setting aside enough time to get in readiness three sterile packages containing (*a*) the drugs, (*b*) the instruments, (*c*) a defibrillator against the day they will be required, and to keep them in a readily accessible specified place in the operating theatre.

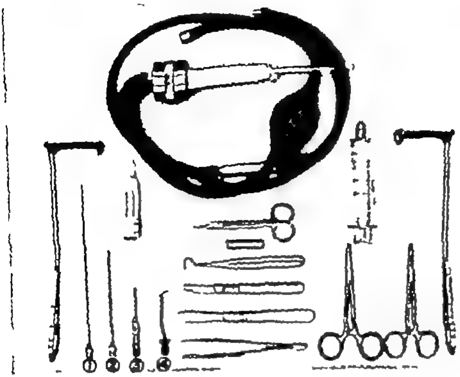

Fig 127.—Equipment for cardiac resuscitation

a. A jar sealed with adhesive tape containing a syringe and needles and the drugs that are shown in *Fig* 126. This is labelled Cardiac Emergency Outfit

b Although it is true that in order to commence cardiac massage a scalpel is the only instrument required, it is far better to have in a sterile package all the instruments and other equipment that are likely to be required for cardiac resuscitation (*Fig* 127).

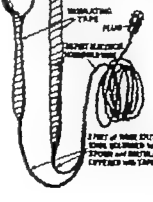

Fig 128.—The construction of a simple defibrillator (*After Max Thorek*)

c. Comparatively few operating theatres are provided with an electric defibrillator of which there are several patterns. Nevertheless one can be constructed with the help of an electrician at a very low cost (*Fig* 128) Faced with ventricular fibrillation, without a defibrillator one is usually powerless.

Ten ml. ampoules of procaine-adrenaline solution are put up by Savory & Moore Ltd., 60 Welbeck Street, London, W 1 The adrenaline deteriorates and the ampoules must be renewed after three months.

CARDIAC ARREST

Cardiac arrest is subdivided into two varieties: (1) Cardiac standstill (syn. cardiac asystole) (2) Ventricular fibrillation.

The initial signs and the immediate treatment of each variety are identical.

Diagnosis.—As a rule it is the anæsthetist who raises the alarm because the pulse becomes impalpable and, if it is not controlled already respiration fails. On being warned of cardiac inhibition the surgeon's first duty if he is operating in a field where there is a large artery is to confirm the absence of pulsation. When such an artery is not available too frequently precious seconds are wasted on auscultation. If the anæsthetist cannot feel the carotid pulse, it is most improbable that the heart-sounds will be audible Far better is it for him to devote his whole attention to the establishment and maintenance of pulmonary ventilation.

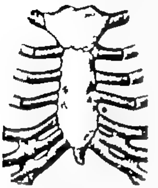

Fig 129.—Where t needle the left ventricle.

Swift and Certain Method of Confirming a Doubtful Diagnosis of Cardiac Arrest.—The surgeon having rapidly sterilized the precordial area, takes a long fine skin needle, or better a lumbar puncture needle, and thrusts it into the 4th left interspace (*Fig* 129), directing its point directly backwards to penetrate the left ventricle This can be accomplished in the twinkling of an eye. If the heart is beating even feebly unmistakable oscillations are transmitted to the needle. It is possible for the stimulus of the prick to restart a heart in asystole. If oscillations are absent, the diagnosis of cardiac arrest is indisputable

Immediate Action is Imperative.—The cells of the cerebral cortex are the most sensitive to anoxæmia,[1] and four minutes without oxygenated blood is almost certain to produce irreparable damage to them.

Time-keeper.—A student, a junior nurse or a porter should be detailed to cry loudly each passing minute from the time the anæsthetist sounds the warning note of danger

The Time Factor.—There are 3½ minutes available between the time the heart ceases to beat and the time when the patient is beyond recall Notwithstanding, one minute should suffice to call into service the dual expedients that alone can keep the patient from death. The first is valueless without the second and the second is of no avail without the first. The two should commence almost simultaneously but ideally the first should precede the second by 15 to 20 sec. The first is applied by the anæsthetist and the second is carried out by the surgeon. The dual procedures upon which the preservation of life depends are —

a. Rhythmic inflation of the lungs with 100 per cent oxygen (automatic respiration)

b Cardiac massage

AUTOMATIC RESPIRATION

The anæsthetist discontinues the administration of anæsthetic agents, and substitutes pure oxygen under pressure[2] If it is not in position already the skilled anæsthetist will pass an endotracheal tube Should the vocal cords be in spasm oxygen blown upon them stimulates them to open A non kinking endotracheal tube with an inflatable cuff is preferred, because it facilitates positive pressure and prevents aspiration into the bronchial tree. A master of endotracheal intubation can pass the tube in 30 sec When the anæsthetist is not particularly skilled in this technique (there are occasions when he may not be provided with a laryngoscope) no attempt should be made to intubate the larynx, for precious time will be wasted thereby Oxygenation of the lungs can be effected by means of a well fitting face-piece either held or harnessed in position after a Hewitt's airway has been inserted. Whether or not an endotracheal tube is in position, a positive pressure of 100 per cent oxygen is maintained by a flow of 10 to 20 litres per minute while 20 times a minute the anæsthetist compresses the rebreathing bag of the anæsthetic machine and so produces forced inspiration He then relaxes pressure, and expiration occurs. Not infrequently respiration controlled in this way has to be carried out for a considerable time—in some cases long after cardiac function has been resumed It must be constantly borne in mind that too much pressure has resulted in rupture of alveoli

[1] The vulnerability of organs to anoxæmia is scaled thus brain adrenals, liver kidneys.

[2] In the absence of oxygen and the apparatus to deliver it, artificial respiration (see p. 99) must be commenced forthwith.

At the earliest opportunity the anæsthetist tilts the operating table 10° by the head. The cerebral cortex can be kept alive by the merest trickle of blood (Sir Leonard Hill).

These imperative duties being accomplished, and after automatic respiration has been proceeding satisfactorily for some minutes, a gastric aspiration tube should be passed to empty the stomach of air and oxygen, but this must not be allowed to interfere with controlled respiration.

While the anæsthetist is actively engaged in bringing oxygen to the pulmonary alveoli, the surgeon should be gaining direct access to the heart in the following manner:—

TRANSTHORACIC CARDIAC MASSAGE[1]

1. Stand on the patient's left side. To have the patient's left arm abducted is an advantage. If it has not been sterilized already, one daub of spirit or other skin antiseptic on the skin of the left thoracic wall is not a waste of time.

2. An incision is made in the 4th interspace, or what is believed to be the 4th interspace without counting the ribs—the 5th interspace affords equally good exposure. The incision commences at the lateral border of the sternum—there is no bleeding—and it passes to the posterior axillary fold (see Spangaro's incision, *Fig.* 1018, p. 738). It is deepened through the muscles. The pleura is opened, care being taken not to wound the dilated heart.

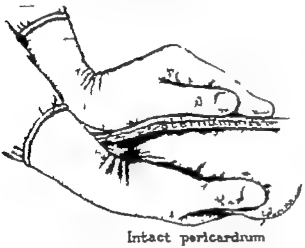

Fig. 130.—Extrapericardial cardiac massage. The heart is compressed against the sternum. (*After Hosler.*)

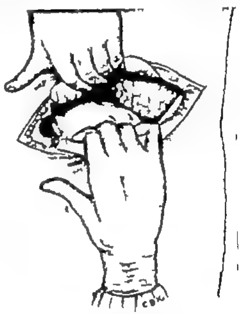

Fig. 131.—Manual retraction of the ribs. (*After S. E. Leeds.*)

3. Pass the right hand into the thoracic cavity, insinuate the palm beneath the heart and the intact pericardium, and compress the heart against the sternum (*Fig.* 130). Rhythmically pressing and relaxing at the rate of once a second, continue for about 25 sec. By this time probably the wrist will become painful from compression by the ribs, but sufficient blood to oxygenate the vital centres will have been delivered to enable the next step to be undertaken without endangering the viability of the cerebral cortex.

4. Withdraw the hand and divide the costal cartilage above and below the incision. Place a mechanical rib-spreader in position or, what is as good or even better, request the assistant to hold the ribs apart (*Fig.* 131). With as little delay as possible slit open the pericardium from apex to base.

5. Recommence cardiac massage in the following way:—

a. If the heart is comparatively large (most adults) pass the right hand behind the heart and lay the left hand on the heart, and compress the ventricles between the hands (*Fig.* 132); blood will be felt to surge out of the heart beneath the fingers. Compression should be gradual and relaxation abrupt—the heart must fill before it can be emptied, and it is necessary to pause between each compression to allow filling, as occurs in diastole. In

[1] If the upper abdomen is open, subdiaphragmatic cardiac massage (see p. 99) should be employed first, but unless a response is obtained, for no more than 30 seconds.

applying compression considerable force must be used but it is distributed evenly with the palmar surface of the fingers. It should be noted that the tips of the fingers which are liable to traumatize the cardiac musculature, take no part in these manœuvres.

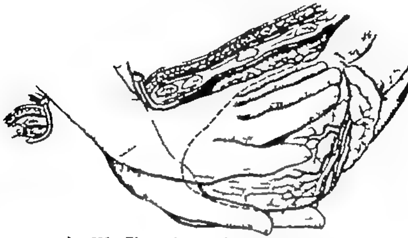

Fig 132.—Bimanual intrapericardial cardiac massage

b If the heart is small enough or the hand of the surgeon is large enough for the ventricles to be encircled by the hand, single handed squeezing (massage) (*Fig* 133) can be carried out, but counter pressure must be made not with the thumb which has been known to rupture the heart but with the thenar eminence.

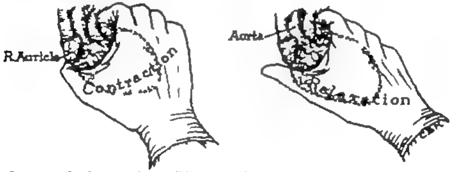

Fig 133.—In the case of a small heart cardiac massage can be performed with one hand.

In either method one must be certain that the right ventricle is emptied as well as the left and that the fingers do not impinge upon the auricles, which are easily traumatized. Cardiac massage carried out at a rate of 60 compressions per minute should produce a blood pressure of 50–60 mm Hg measurable by the anæsthetist The artificial circulation of oxygenated blood brings about a sustained improvement in the patient's colour

6. *Shortly after intrapericardial massage has been commenced the theatre sister takes* a 10-ml syringe and proceeds to fill it with (*a*) 0·5 ml. of adrenaline hydrochloride 1–1000 followed by (*b*) 9 5 ml of 1 per cent solution of procaine, i.e. 10 ml. in all (Lahey's mixture[1]). The dose of each drug is checked by the surgeon while cardiac massage is in progress. If the patient is old physically debilitated, or a child it is advised to inject only 5 ml

7 After 2 minutes of sustained intrapericardial cardiac massage without response is *the time for the intracardiac injection.*[2] *The few seconds respite from cardiac massage* affords a real opportunity to view the heart with a critical eye —

a Does it remain motionless and flaccid ? = cardiac arrest.

b Are there inco-ordinated fibrillary twitchings of most, if not all of the individual muscle-bundles ? = ventricular fibrillation.

[1] The 10-ml ampoules of this mixture illustrated in *Figs*. 126, 127 are advised.

[2] Opinion regarding the best solution to inject is not stereotyped. A large number of workers in this field consider that the procaine-adrenaline solution advised here cannot be bettered. Others employ 2–10 ml of a 10 per cent solution of calcium chloride still others are convinced that 3 ml. of 10 per cent solution of barium chloride is unequalled. If thoughtful pre-arrangements are made there is no difficulty in including ampoules of both calcium chloride and barium chloride in the cardiac emergency outfit.

These observations are made while the contents of the syringe are being injected into the right auricle. *Intraventricular* injection should be avoided because of the risk of inducing ventricular fibrillation in an asystolic heart. Intraventricular injection of adrenaline without procaine into an asystolic heart is especially liable to produce ventricular fibrillation when the patient has been anaesthetized with chloroform, trilene, or cyclopropane.

8. As soon as possible recommence cardiac massage. If necessary two further intracardiac injections are given at intervals of 5–10 minutes respectively. It is advised not to repeat the procaine-adrenaline solution, but to give 3 ml. of 10 per cent calcium chloride which can do no harm, and may restore cardiac function.

9. Cardiac massage becomes very tiring and when the surgeon feels his hands are aching it must be punctuated by short intervals (2–3 sec.) of rest. This is fortunate because massage should be interrupted at regular short intervals, in order to allow spontaneous beats to develop. If feeble heart beats are observed and they do not get stronger they must be assisted (*see below*).

In protracted cases, if the assistant is competent to do so, he can relieve the tired surgeon for a spell at agreed intervals.

OTHER CONSIDERATIONS

The Use of Tourniquets.—Lucas states that placing an arterial tourniquet around each arm increases the blood flow to the brain. While performing cardiac massage, Woodward ordered Esmarch's bandages to be applied to the lower limbs; the heart became twice its former size and temporarily started beating.

Compression of the Thoracic Aorta.—With a view to enhancing the blood flow to the brain and the heart, a few surgeons advise compressing the thoracic aorta just distal to the left subclavian artery while cardiac massage is in progress. This step cannot be recommended for the following reasons: firstly, the assistant applying aortic compression gets in the way of the surgeon performing cardiac massage. Secondly, although aortic compression amplifies the cerebral and coronary circulations, it does so at the expense of the corporal circulation. Consequently even if the heart beat is restored, irreversible shock from anoxaemic damage of the adrenals is liable to supervene.

Do not give Blood Transfusion or Intravenous Infusion during the Period of Cardiac Arrest or Ventricular Fibrillation.—When cardiac function has been restored, then each case must be treated on its merits. As a rule intravenous fluid should be given slowly and with great caution.

RESUMPTION OF CARDIAC ACTIVITY

At any time during the tense minutes that are being called by the timekeeper the heart in asystole may restart beating by massage alone. Not infrequently one contraction takes place, but the heart does not continue to beat. In nearly all such cases it requires only a little perseverance with massage to experience the incredible satisfaction of feeling and then seeing the heart spring into automatic activity. Usually the beats are strong, and the earlier they are resumed the more likely are they to remain so.

Assisted Massage.—When the heart is beating feebly it must be assisted. Every two or three beats two fingers of one hand are placed behind and two fingers of the other hand in front of the heart, and its systole is reinforced by compression. In this way the surgeon can observe the beats and reinforce those that are inadequate (Hosler). (Compression of the heart between the fingers is used in cardiac arrest in the newborn.)

FOR HOW LONG SHOULD CARDIAC MASSAGE BE CONTINUED?

In the absence of resumption of cardiac activity this difficult question must be faced. It is often stated that 60 min. is the limit. True that by this time one surgeon and one assistant alternating are extremely tired, but in favourable circumstances they can be relieved by another team. As will be appreciated after the next paragraph has been read, no doubt some cases are abandoned prematurely, and by perseverance it is possible to recall some whom Charon has commenced to ferry across the river Styx.

Some Noteworthy Cases.—In a case of cardiac arrest during exchange transfusion in an infant a few hours old, Pew performed cardiac massage with success.

After two hours of unsuccessful cardiac massage, 3 ml. of barium chloride was injected into the left ventricle and beating of the heart recommenced (Stephenson et al.).

In a case of cardiac arrest following thiopentone anaesthesia, cardiac massage proved successful after 3 min. but the patient remained unconscious for ~ days (Louttit)

Several teams continued cardiac massage for 8 hours in a patient who is now practising as a lawyer in New York City (M. H Foote)

Expectation of Survival.—Twenty-eight per cent of 1200 patients with cardiac arrest collected by Stephenson et al. recovered completely Of those who died, 87 per cent did so within the first 24 hours only 3 per cent died after 8 days. In a number of smaller series where transthoracic massage has been employed almost exclusively the percentage of recoveries has been higher than in this large series.

VENTRICULAR FIBRILLATION

Ventricular fibrillation is less common than cardiac standstill, and the prognosis is less favourable. The condition can be diagnosed only with certainty[1] by direct inspection of the heart with the pericardium opened, or by electrocardiography As has been emphasized already the appearance is quite characteristic. It can be seen at once that the heart is not functioning yet all its muscle-fibres are in independent inco-ordinated motion (Fell).

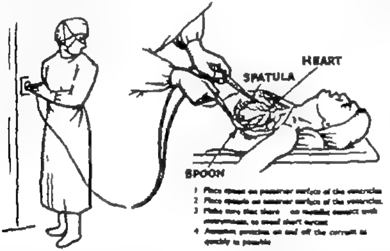

Fig 184 —Defibrillation of the heart. (*After Max Thorek*)

The initial treatment is precisely the same as that of cardiac standstill - indeed as has been explained, as a rule it is only after the first real opportunity to view the ventricles prior to intracardiac injection that the condition is distinguished from cardiac asystole It should be noted that in at least 3 reported cases ventricular fibrillation has commenced only after adrenaline (without procaine) had been injected into the ventricle for cardiac standstill.

As soon as ventricular fibrillation is observed, the first thing to do is to flick the heart with the finger occasionally this restores contraction. The second thing to do is to inject the contents of the already loaded syringe of procaine-adrenaline solution (*see footnotes* pp. 91 and 94) into the right auricle or as some prefer into the right ventricle In 7 reported cases ventricular fibrillation has ceased, the heart beats have recommenced, and recovery has ensued following this injection. More usually cardiac massage must be continued until an electric defibrillator is available. The operator must be fully insulated with rubber gloves, and the handles of the electrodes must be heavily insulated. The electrodes are placed on either side of the heart, and sufficient pressure is exerted to empty the heart (*Fig* 184) It should be noted that in order to defibrillate the heart completely one must bring the electrodes as close together as possible by compressing the heart between them. The current[2] is then switched on for one full second, i.e. while the words one thousand are spoken. The electric shock may —

1 Cause the heart beats to recommence.
2. Initiate asystole.
3. Produce no change

[1] Occasionally the diagnosis of ventricular fibrillation can be made when the heart is first grasped ; instead of being flabby and still it feels like a bag of worms

[2] Ordinary household current (voltage 220–230) is used, but it must be A.C. ; D C is useless.

After a further period of 2 or 3 min. of cardiac massage an intracardiac injection of 5 ml. of 10 per cent solution of calcium chloride is strongly recommended by Milstein and Brock, because it may increase the tone of the myocardium from feeble to coarse fibrillation, which then responds to massage or further electric shock. When co-ordinated beats are resumed, often the heart remains motionless for a second after the current has been withdrawn; then there is a sudden forcible beat. At other times co-ordinated rhythm is resumed with weak, ineffectual beats that must be assisted (see p. 95). The sequence, massage—injection of calcium or barium chloride—massage—electric shock, must be continued at intervals of 10 min. for at least 80 min. In 14 cases reported by Milstein and Brock these measures proved successful in 6 cases. In some cases the heart appears to resume its pristine rhythm, but an effectual blood-pressure is not maintained. It must then be presumed that the cause of the low blood pressure is peripheral circulatory collapse (shock), and an intra-arterial blood transfusion is indicated.

CARDIAC FUNCTION RESUMED: PERIOD OF OBSERVATION [ALL CASES OF CARDIAC ARREST]

As soon as the heart commences to beat the internal mammary artery must be ligated. At this juncture there arises the all important question of undertaking or completing the original operation.

If the operation was not commenced (a number of cases of cardiac arrest occur during the period of induction), if it is possible the operation is postponed. If postponement is not feasible, the simplest procedure that will save life is undertaken.

If the operation was interrupted, it must be completed as expeditiously as possible. While these imperative procedures are being carried out, if a mechanical retractor has been used to spread the ribs, it is left in position, and the beating heart is covered with two or three layers of moist gauze, which permit the heart beats to be observed. Continuous direct observation cannot be undertaken if the ribs were held apart by an assistant.

There should be no hurry to close the thorax. The heart must be observed for a sufficiently long time to feel assured that it is unlikely to stop again. The minimum period of observation should be 10 min.

CLOSING THE THORAX

1. The edges of the pericardium are united loosely with interrupted sutures.

2. Be positive that the internal mammary artery has been ligated.

3. A series of strong interrupted sutures are placed around the adjacent ribs with a large curved needle passing through the intercostal space above, and out through the intercostal space below. The sutures are left untied *pro tem.*

4. If a rib approximator is to hand, this is applied. Rake retractors to pull the ribs together are a good substitute. If neither is available the assistant must press the adjacent ribs together with his fingers while the pericostal sutures are tied.

5. Before the last of these sutures is tied, a rubber catheter is passed into the pleural cavity.

6. The muscles and fascia are brought together with interrupted sutures.

7. The skin is sutured. It is important not to transfix the tube with a stitch that will probably cause an air leak. A double knot is tied in a piece of strong silk, leaving a loop. The free ends encircle the rubber catheter and are tied as tightly as possible at skin level without encroaching upon its lumen. The loop and the free ends of the silk are anchored to the skin by adhesive plaster as shown in *Fig.* 18.

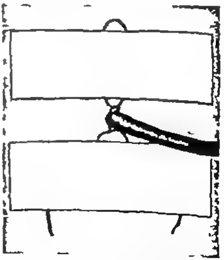

Fig. 18.—Method of anchoring the catheter without transfixing it with a stitch.

8. The lungs are inflated fully by the anæsthetist, and the tube is clamped with a hæmostat. Later when the patient has been transferred to his room or ward, the tubing is connected to a water-seal drainage system.

Alternatively some thoracic surgeons recommend removal of the tube as soon as the lungs have been inflated fully and closing the tract by inserting a deep suture. Subsequently pleural fluid accumulations are removed by timely aspiration.

8 The dressings are kept in place by strips of adhesive plaster that do not extend far enough to restrict the movements of the opposite side of the thorax.

IMMEDIATE AFTER TREATMENT

The patient should be kept in the operating theatre or in the anæsthetic room or if it is available in a room near the operating theatre for several hours. As soon as his condition warrants it he can be transferred to a bed which has been brought thither. The patient should be kept flat or in a very slight Trendelenburg position until he has regained consciousness. It is desirable to have the right (unoperated) side at a slightly higher level than the left, and to ensure that the right side of the thorax is unimpeded by bandages or bedclothes.

In some instances almost as soon as the heart starts beating the patient breathes spontaneously; in others controlled respiration must be continued, sometimes for a long period, and the intratracheal tube or the Hewitt's air way and the well-fitting mask, should not be removed until it is absolutely certain that the patient will breathe naturally. A most valuable procedure when spontaneous respiration is delayed is endotracheal suction. Suction acts as a respiratory stimulus; in addition it clears the bronchial tree which is sure to be full of secretion.

The room should be cool and the patient lightly covered. No hot water-bottles are employed. The pulse blood pressure, and respiratory rate should be recorded every 10 min. for the first few hours. Sometimes the blood pressure gradually falls, and in such cases the diagnosis of delayed shock is the usual explanation. In these circumstances probably the best that can be done is to administer a slow intravenous drip with noradrenaline (*see* p. 77). The temperature should be taken every hour for the first 6 hours. A rapid rise of temperature usually indicates cerebral œdema, which is the most frequent cause of death in those patients on whom cardiac resuscitation has been performed successfully. Cerebral œdema consequent upon cerebral hypoxia is the particular danger where there has been a delay of more than 3 min. in commencing automatic respiration and cardiac massage.

Threatened or Established Cerebral Œdema.—In established cases the patient is comatose, with stertorous respirations frequently accompanied by a tracheal tug. The temperature is elevated and may rise to 105° F (40·6° C.). Sweating is pronounced. Usually the pupils are dilated, but sometimes they are constricted; nystagmus is not infrequently present. Some of the patients are restless, with twitching movements of the limbs. Convulsions occur at a later stage.

A general lightening of the depth of the coma with a return of voluntary movements and a response to painful stimuli usually heralds recovery; respiratory rhythm and the temperature then gradually return to normal. On the other hand deepening coma, a rapid pulse, Cheyne-Stokes respiration, flaccidity, loss of deep reflexes, and hyperpyrexia are the precursors of impending dissolution.

Treatment, to be effective, must be commenced early. It is of cardinal importance to dehydrate the œdematous brain. To this end 40 ml. of 50 per cent sucrose is injected intravenously and 15 minutes is allowed to elapse in order to assess the result, which is seldom dramatic, but some lightening of the depth of unconsciousness should occur. After 15 minutes a further injection of 40 ml. of 50 per cent sucrose is given and, according to the response, following an interval of 30 minutes another 20–40 ml. is injected. After this a drip of 10 per cent dextran in normal saline solution, 30 ml. per hour, is usually advisable. If they occur barbiturates intravenously are necessary to control convulsions.

During the whole of this treatment a very slight head-down tilt of 7°—not enough to cause cerebral congestion but sufficient to aid the elimination of bronchial secretions—is adopted. Hypothermia is induced by covering the patient with a sheet and directing the current of air from an electric fan advantageously. Icepacks are only resorted to if these measures do not cause the temperature to fall to under 100° F (37·8° C.). Fluids are restricted and the aid of gastric aspiration and oxygen therapy is invoked.

Other Considerations.—After the heart has stopped beating and cardiac resuscitation has been carried out successfully it is always advisable to call in a physician who with the aid of electrocardiography will advise as to special treatment to support the heart.

At the same time he will undertake the treatment of pulmonary complications, should they arise Having secured the services of a physician it is usual to request him to supervise the antibiotic therapy which certainly should be commenced as soon as the crisis is over

SUBDIAPHRAGMATIC CARDIAC MASSAGE

Until about a decade ago this was the method that was practised almost universally The results were inferior to present-day methods. As stated already subdiaphragmatic cardiac massage is still indicated as a preliminary measure in cases where the upper abdomen is already opened, but it is fundamental to realize that subdiaphragmatic cardiac massage remains the method of choice when facilities for controlled respiration are lacking In such circumstances, if transthoracic cardiac massage is employed the left lung collapses, and pulmonary ventilation is reduced to performing artificial respiration on the right lung only

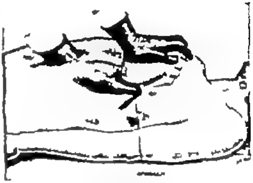

Fig 136.—Subdiaphragmatic cardiac massage in progress.

Technique.—With a sweep of the knife the upper abdomen is entered in the midline immediately beneath the xiphisternum The incision must be long enough to admit the hand. When counterpressure is exerted by the base of the left palm on the lower left costal margin, effective intermittent pressure can be exerted on the ventricles by the pulps of the fingers of the right hand beneath the diaphragm (*Fig* 136) For the first half minute these movements should be quick and forcible After half a minute (so as not to overtire the hand) the movements should become slower

BLUE ASPHYXIA

As opposed to cardiac arrest, which gives rise to what is sometimes known as white asphyxia blue asphyxia is caused by respiratory obstruction, or less frequently by inhibition of the respiratory centre. Blue asphyxia is not now encountered nearly as often as formerly modern anæsthesia with controlled respirations through an endotracheal tube is the reason for the steep decline None the less, when anæsthetics without endotracheal intubation are given—and these still constitute a large percentage—from time to time blue asphyxia will occur in cases of both inhalation and intravenous anæsthesia. Moreover blue asphyxia is far from uncommon during the period of recovery from anæsthesia.

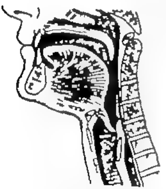

Fig 137 —Impaction of the epiglottis.

In all cases it is assumed that the anæsthetist has cleared the airway pulled the tongue forward, and is administering oxygen. In this connexion the remote possibility of impaction of the epiglottis should always be borne in mind. That impaction of the epiglottis (*Fig* 137) can and does, occur during anæsthesia is emphasized by Caiger who has encountered it six times, and has relieved the condition by drawing the tongue forward and lifting the epiglottis with the finger On one occasion disimpaction produced an audible click.

Artificial Respiration.[1]—(Presuming that facilities for automatic respiration (*see* p 92) are lacking) On receiving a request from the anæsthetist for artificial respiration the most usual practice is for the operator to exert rhythmical pressure on the lower thorax. Useful as this method is, it should not be carried on for more than a minute. If after this period, respiration has not recommenced, the field of operation, if near the thorax, should be covered with a sterile towel securely clipped by towel forceps to prevent it becoming displaced. Silvester's artificial respiration (*Fig* 138) is then carried out slowly systematically and symmetrically usually by the surgeon's assistant who summons an unoccupied helper

[1] When facilities for automatic respiration are not available one of these methods of artificial respiration is essential, not only in blue asphyxia, but in every case of respiratory failure.

The Direct Method (*Fig* 139) is valuable in an extreme emergency when assistance is at a low ebb or non-existent. A piece of gauze is placed over the patient's mouth and the medical attendant blows through it gently while the nose is pinched and the lower jaw is held forwards with a thumb behind its angle or what is better the tongue is drawn forward

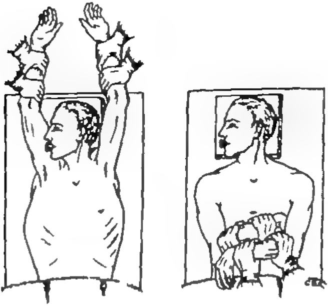

Fig 138.—Silvester's method of performing artificial respiration.

with a towel clip or a stitch. There is no resistance to overcome the air easily enters and inflates the lungs, and is expelled automatically or rather gurgles out with the help of gentle pressure on chest or abdomen. The process is repeated every four or five seconds until normal rhythmical respirations are restored. Blue asphyxia is seldom an occasion for grave concern. If treated effectively the condition is remedied in a few minutes.

Fig 139.—Direct method of inflating lungs.

Unrelieved, blue asphyxia culminates in cardiac arrest. In such cases the time limit for successful cardiac resuscitation is lengthened tremendously this is in keeping with what we might expect from a theoretical consideration. In blue asphyxia the cerebral mechanism is not deprived of blood indeed it is congested with stagnant venous blood, and because of this the cerebral cells survive longer than if the congestion were not present.

Cardiac Massage in Late Blue Asphyxia.—

I happened to be on my way to visit another patient, when an agitated nurse ran out of a room saying " He is very blue On entering the room a man aged 28, from whom I had removed the left submaxillary salivary gland for calculus about three-quarters of an hour previously was lying quite still. His face was suffused and deeply cyanotic. I pulled his head and shoulders to the side of the bed inserted the mouth-gag which was on the bed-table, put my right index finger down to the back of his throat, and attempted to perform artificial respiration by placing the base of my left hand over the xiphisternum. As soon as an airway had been established it was surprising to find how effective was this method of getting some air in and out of the lungs. After about a dozen compressions the patient made one respiratory effort. This, the only sign of life, was not repeated. I had sent the nurse to fetch Sister and anyone else available. At last the nurse returned with the news that Sister was at dinner she was accompanied by another nurse. I exhorted them to find someone. Possibly a minute later Dr Marre, who had come to visit a patient appeared. Dr Marre performed artificial respiration while I swabbed out the pharynx. After about two minutes we came to the conclusion that there were no signs of life, and I asked Dr Marre to go to the theatre and fetch a scalpel. This he did, and returned after what seemed to be a very long time but afterwards we estimated it was five minutes (the theatre was on another floor). During all this time I continued to perform artificial respiration. The scalpel was in a bowl of spirit and having rinsed my hand, which was lacerated by the patient's teeth, in running water I dipped my hands in the spirit and then poured some spirit upon the patient's epigastrium. Having incised the epigastrium in the middle line, subdiaphragmatic cardiac massage was carried out and, after about 1½ minutes, there were as I have experienced before one or two beats followed by further cardiac cessation. Continuing the massage for some seconds, the heart sprang into activity and shortly afterwards the patient began to breathe naturally The instruments for sewing up the abdomen were sent for (by this time numerous helpers had arrived on the scene), and the abdomen was closed.

Fig 140.—W F., 2 years after his remarkable resuscitation.

One hour later the patient was breathing well, the pulse-rate was about 120 and steady the pupils were widely dilated and fixed, and the conjunctival reflex was absent. The face was still very suffused, and the purple tongue, which had been torn by my endeavour to draw it forward, continued to bleed ; consequently the pharynx had to be swabbed out periodically By midnight the pupils were smaller but the conjunctival reflexes were still absent. The patient became restless at 12.30 a.m. and periodic attacks of restlessness occurred during the night. At 4.30 a.m. he showed signs of cerebral irritation and had to be held in bed. One-quarter gr (16 mg) of morphine[1] was given. By 5 a.m. the pulse rate was again down to 120 but at 8 a.m extreme restlessness returned. Another ⅙ gr (10 mg) of morphine was administered. At 10.30 there was generalized sweating The blood pressure was 116/78 The pupils were pin-point and equal, but there was no reaction to light. The limbs were somewhat spastic and, what was profoundly disappointing there was no sign of return to consciousness. However 13½ hours after the cardiac massage the patient began to swallow and from this time hope of a successful issue was entertained. He spoke to the nurse 17 hours after resuscitation. He then continued to improve until the seventh day when suddenly he experienced very severe pain in the left side of the abdomen. This was diagnosed (after difficulty) as diaphragmatic pleurisy which proved to be the case. A left pleural effusion and later an empyema developed. The patient recovered (*Fig* 140).

The case shows that in cardiac arrest following blue asphyxia the time limit for successful cardiac massage is lengthened very considerably

VOMITUS INSPIRED DURING ANÆSTHESIA

(*See also* p 144)

When it is probable that the patient has inspired vomitus, it is essential to make use of the aid of gravity at once by tilting the whole table by the head. When artificial respiration is required, it should be performed by Silvester's method. *Controlled respiration with positive pressure is contra indicated absolutely* it would force the inhaled vomitus into the alveoli

If possible the fluid in the trachea should be sucked out with a catheter passed through the vocal cords by the anæsthetist. Even the bronchi can be aspirated in this way

[1] In these circumstances an injection of a barbiturate is better than morphine which depresses the respiratory centre

Alternatively immediate tracheotomy and the insertion into the trachea of a catheter connected to a sucker has proved a life-saving measure. One or other of these thorough procedures is essential, as also are post-operative antibiotic therapy postural percussion drainage and breathing exercises. When, in spite of these measures lobar or massive collapse of a lung follows, and the collapse cannot be relieved by postural percussion drainage or endotracheal suction, it is probable that a piece of food is impacted in a bronchus, and the services of a bronchoscopist should be enlisted as soon as possible. Only by these means can bronchopneumonia—usually fatal bronchopneumonia—be averted.

The prevention of this accident lies in emptying the stomach before operation and in necessary cases, i.e. intestinal obstruction, keeping it empty throughout and after the operation, as is emphasized in many places in the chapters that follow

Muscle relaxants, which render the œsophageal sphincter atonic, have led to an increased incidence of vomitus inspired during anæsthesia. The insertion of an endotracheal tube with an inflatable cuff valuable at all times, should never be omitted if muscle relaxants are to be used. As long as the inflated cuff is in place, this extremely dangerous accident is impossible.

ANÆSTHESTIC (ETHER, PROCAINE) CONVULSIONS

Convulsions during anæsthesia are often very severe, and carry a high mortality The cause or causes of these convulsions are not yet fully understood. They are variously attributed to excessive heat in the operating theatre, over-atropinization, acapnia, or to the patient having inborn, but latent, epileptic liability but often none of these is present. The clinical manifestations (*see below*) are always the same, and apparently almost every anæsthetic agent can give rise to them, although most reported cases have occurred during the administration of ether or during or after the infiltration of a local anæsthetic. From the practical standpoint it should be emphasized that the treatment is identical whether the convulsions occur from the use of a general or a local anæsthetic. It is of paramount importance to know what to do and not to delay in doing it, for every minute of convulsions makes the prognosis more grave.

Treatment.—Carbon dioxide and oxygen should be administered at once and the sooner an intravenous injection of thiopentone can be given, the better In practically every case after the injection of 3–5 ml. of this drug the convulsions are controlled. If necessary the intravenous injection can be repeated. Oxygen and carbon dioxide should be continued for some time after the convulsions have ceased, and an injection of lobeline to stimulate the respiratory centre appears to be useful.

Ether Convulsions.—

While operating upon a patient of 85 with a stone impacted in the common bile-duct ether convulsions started, and it was evident that unless a powerful antidote was forthcoming immediately the patient whose pre-operative condition was poor would expire. In spite of the fact that thiopentone is contra-indicated when liver function is depressed, an injection of this drug was decided upon. When 3 5 ml. had been injected intravenously a fit was at its height; the patient gave a long inspiration—almost a yawn—and from that second the fit ceased, and no more followed. The operation was completed while the anæsthetist administered carbon dioxide and oxygen. The pulse was steady but the volume poor As soon as the carbon dioxide and oxygen were discontinued respirations became feeble. A quarter of an hour later there was no substantial improvement in this respect. At this juncture an injection of lobeline was given. Within five minutes there was some improvement, and a second injection was given with a remarkable increase in respiratory ventilation. The patient recovered.

Venepuncture in a child having convulsions[1] is extremely difficult. Angus Smith states that convulsions can often be stopped quickly by raising the patient to a sitting position. Raising the head of the table or adopting the sitting posture is recommended by other anæsthetists, and it should certainly be tried if venepuncture has failed. However the standard treatment of anæsthetic convulsions is: oxygen with carbon dioxide is administered. Ordinary thiopentone[2] 5 per cent solution is injected very slowly to the point of cessation of convulsive movements. If the convulsions return, the treatment can be repeated.

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[1] When intravenous injection is impossible, intracardiac injection is the only alternative.

[2] Although thiopentone is excellent for treatment it must be mentioned that thiopentone itself can cause convulsions, but they are of a localized type occurring mostly in the muscles of the arms, thorax, and larynx.

An anæsthetist experienced in their use will probably choose one of the curare-like relaxant drugs, which will cause convulsions to cease in all cases.

Procaine Poisoning.—Local anæsthesia is rightly considered to be very safe, even so it has its dangers. Firstly, there may be an abnormal sensitiveness to the drug arising from a previous injection; this has been noted by several observers. Pallor, rapid pulse and low blood-pressure come on a few moments after the injection of even a small quantity. Fortunately, in most instances there is an immediate response to lowering of the head and the injection of a pressor substance.

Convulsions.—What is more serious is true procaine poisoning. It is possible that certain individuals have an idiosyncrasy to the drug. Nevertheless, it is more than probable that in most instances the procaine has been allowed to enter a vein. The symptoms are as follows: the patient loses consciousness and suddenly the whole body becomes convulsed in a terrifying fit. Jactitations may be so violent that the limbs bang against the table. The danger lies in the failure of the respiratory centre, which gives out before the cardiovascular centre. These convulsions can occur following the infiltration of any local anæsthetic.

Prophylaxis.—The value of barbiturates in combating poisoning by drugs of the cocaine type is well proved, therefore the use of a barbiturate for premedication is a wise choice.

Treatment is exactly the same as that described for all anæsthetic convulsions.

COLLAPSE UNDER SPINAL ANÆSTHESIA

Golden Rules for Prevention.—

1. Take the blood-pressure before commencing and never give a spinal anæsthetic to a patient with a blood pressure under 110 mm. Hg.

2. Unless the patient's blood pressure is abnormal always give an injection of a pressor substance soon after the spinal anæsthetic has been administered, to counteract the fall in blood pressure, and keep a second dose at hand in case of emergency. For this purpose methedrine[1] is good, but S-methylisothiourea[2] is even better. In each instance, the contents of one ampoule is given intravenously.

3. It is an excellent practice to gravitate dextrose saline solution into a vein at a slow rate throughout the operation. The needle or cannula should be inserted after the spinal anæsthetic has been given, but before the operation is commenced. The pressor substance alluded to above can be given into the tubing of the apparatus. At any time during the operation, should the blood pressure fall, the solution can be given at a faster rate and a second dose of the pressor substance can be injected into the tubing.

There are two "danger periods" in spinal anæsthesia. The first is almost directly after the injection, and the second is fifteen to twenty minutes later. The danger lies in a fall of blood pressure and can be shown by the sphygmomanometer. If the signs of collapse are marked, tilt the table further by the head, for probably the blood is gravitating into the paralysed arterioles in the anæsthetized area. This postural correction of blood pressure is usually effective, and should be combined with the second dose of a pressor substance.

COLLAPSE UNDER INTRAVENOUS ANÆSTHESIA

Picrotoxin is said to be antidotal to thiopentone. It is given intravenously in 1–10 000 solution. 1 mg. of picrotoxin is antidotal to 30 to 40 mg. of thiopentone.

[1] Methedrine—Burroughs Wellcome & Co.
[2] S-methylisothiourea—British Drug Houses Ltd.

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CHAPTER X

AIR EMBOLISM

It is of paramount importance to know that there are two varieties of air embolism—venous and arterial—the clinical manifestations of which are dissimilar. To this prima facie all-sufficient classification must be added paradoxical air embolism—a venous air embolus that becomes arterial by travelling from the right to the left auricle through a patent foramen ovale. It is true that in 5 to 8 per cent of adults this foramen is patent, but in the great majority the opening is no larger than the bulbous end of a standard probe, and in only 0 5 per cent of these does the valvula foraminis ovalis fail to cover the opening. Consequently the chances of meeting with a case of paradoxical air embolus are very small indeed.

This cannot be said of air embolus in general. To review the literature on this subject is to be astounded at the number of cases reported, many in journals devoted to specialized subjects. Even so one must reflect that the disaster occurs more frequently than reported cases would seem to indicate. Furthermore, in fatal cases where the true diagnosis is unsuspected, death is often attributed to pulmonary embolus, coronary thrombosis, or heart failure. Even at necropsy many cases are missed by a slovenly technique (Keith Simpson). A not uncommon post-mortem finding is slightly blood-stained froth about the mouth and nostrils. To simplify post mortem diagnosis J D Taylor recommends X ray examination of the head and trunk of the cadaver before undertaking the post mortem examination. Death in venous air embolism is characterized by primary respiratory failure due to obstruction at the mouth of the pulmonary artery (Oppenheimer et al.)

VENOUS AIR EMBOLISM

In a healthy individual approximately 100 ml. of air is necessary to cause death by venous air embolism, but much depends upon the speed of injection the pressure at which it is injected, and the posture of the patient during and soon after the injection. Experiments alleged to have been conducted in German concentration camps indicate that a considerable quantity of air could be injected intravenously without a fatal issue, provided the victim was kept in the head low right-side-uppermost position during and for some time after the injection. If the recipient is in poor health, a much smaller quantity may determine a fatal issue. In many of the necropsies performed by Keith Simpson the total amount of air that caused death cannot have exceeded 10–15 ml.

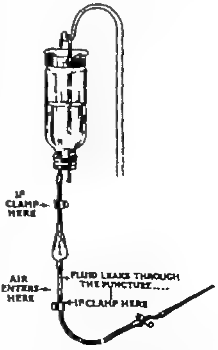


Fig. 141.—The behaviour of punctured and cracked tubing in relation to the screw clamp. (*After Birch.*)

The variety of ways that air can be sucked or injected into the venous system is truly remarkable:—

During the Collection of Blood from a Donor.—A number of fatal and, happily (following correct treatment) not a few non-fatal cases have occurred during the collection of blood, usually by the vacuum bottle method. In most cases cited there has been a positive (instead of a negative) pressure or at any rate a lack of vacuum in the collecting bottle. The way the accident occurs is as follows: the needle having been introduced into a vein, blood does not flow; the patient is asked to open and close the hand. There is still no flow so the tourniquet is loosened, and air from the bottle passes along the tubing into the vein. In order to detect a loss of vacuum in a blood-collecting bottle Don Baxter of Baxter Inc., gives the following instructions: Shake the bottle. There is an easily noticeable difference

in the sound produced when air is present, or absent. To obviate this danger the Baxter Company are providing special tubing that dimples if a vacuum is present.

During Continuous Intravenous Fluid Therapy.—

a. The Reservoir is allowed to run dry.—Unfortunately this is not the almost unheard-of accident that we are sometimes led to believe. Particularly if it occurs during the night, the empty bottle may have been replaced by a full one before the medical officer arrives on the scene. Unless he is told of the happening it is unlikely that he will be able to distinguish the symptoms caused by air embolism from those of pulmonary embolism or coronary thrombosis. The only real safeguard against this accident is to employ an interceptor containing a ground-glass float, which, in the event of the container being allowed to run dry, is self-sealing.

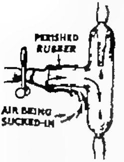


Fig. 142.—Air being sucked in between the glass by past and perished rubber tubing. (*After Keith Simpson.*)

b. Air can enter through Punctures in the Tubing.—Drugs are often injected into the tubing of an intravenous set in lieu of injecting them directly into a vein. Whether the puncture remains potentially patent or not depends upon the quality and age of the rubber tubing; polythene and nylon tubing cannot be expected to be self-sealing. When the tubing is cracked or punctured air is liable to be sucked into the lumen by the gravitating fluid (*Fig.* 141). If the screw clamp instead of being on the tubing between the reservoir and the drip chamber is placed 6 in. (15 cm.) above the needle or cannula, this untoward possibility is obviated (Devas).

c. To employ a Martin's pump in order to accelerate transfusion or infusion when the tubing contains even one puncture is extremely dangerous, for air is sucked in through the puncture (Langmaid and Mushin).

d. That still widely used interceptor with a side channel has so many times proved a cause of death from air embolism that it should be banned officially. *Fig.* 142 shows one of several methods by which air is permitted to enter the infusion and transfusion set via this unnecessary side channel.

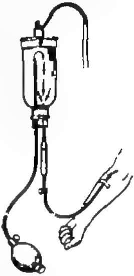


Fig. 143.—Mode of entry of air when blood in bottle is exhausted.

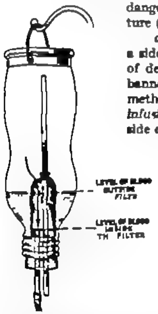


Fig. 144.—Clots on the side of the gauze filter will maintain an apparently safe level of blood in the bottle while the blood level within the filter falls to zero, and permits air to enter the delivery tube. (*After Mollison.*)

e. When infusion, or more usually transfusion, is hastened by attaching the tubing and bulb of a sphygmomanometer (*Fig.* 143) or a Higginson's syringe to the air inlet, unless the person in control of the pump is ready to clip the tubing with a hæmostat before the bottle runs dry, a large quantity of air under pressure is liable to enter the vein. The only way of not being taken by surprise at the speed with which the last few ounces are driven from the bottle is to be ready to apply the hæmostat to the tubing when the contents of the bottle has reached the low level of 2 in. (5 cm.) from the bottom.

f. Due to a Blocked Filter during Blood Transfusion.—Another more subtle, cause of air embolism during blood transfusion is due to the lower part of the filter becoming covered with blood-clot or slime so that blood cannot pass through it. The level of the blood within the filter can then fall more rapidly than the level of blood outside the filter. In these circumstances it is possible for air to enter the upper (unclogged) part of the filter and pass through the outlet, although the level of blood in the bottle appears to be a safe distance above the outlet (*Fig.* 144). This accident is more likely to happen if the same filter is used for more than one bottle of blood. It can occur with both positive pressure and gravitation transfusions.

g. Endeavouring to introduce a cannula into a poorly filled vein *after* the tourniquet has been removed is an unforgivable error that is sometimes perpetrated. Air enters while the incision in the vein is being held open to admit the tip of the cannula.

h. The occasional technical error of passing the cannula retaining ligature through the vein wall (*Fig.* 145) is, when the ligature is tied instrumental in providing a channel for the ingress of air alongside the cannula.

During the Induction of an Artificial Pneumothorax air embolism is a relatively frequent catastrophe, the incidence being approximately 1 in 600 injections (including refills) with a mortality of not less than 80 per cent. As a rule the air is injected into an intercostal vein or a radicle thereof and passes into the azygos system, from whence it is carried to the heart and/or if the patient is in an upright position, air bubbles rise, by pass the innominate vein, to enter the superior vena cava and via the jugular vein reach the brain. More rarely the air is injected into a tributary of the pulmonary vein thereby giving rise to an arterial air embolus, and often sudden death. Pleural shock is now known to be due to air embolism

Fig. 145.—Ligature passed through a vein. After tying air is sucked alongside the cannula. (*After Keith Simpson.*)

During Thoracoscopy.—Relatively few cases have been reported from this procedure.

During Operations upon the Lungs, especially during thoracoplasty When a vein encased in fibrous tissue is divided it is liable to be held open by the adhesions.

During Angiocardiography.—In Durant's patient air entered the cardiac catheter while changing the syringe containing saline solution for that containing diodrast. Stertorous breathing was quickly followed by convulsions, and the patient passed into deep coma. Postural treatment was adopted at once, and oxygen was administered. This was the first and only example of a radiograph being taken showing an air embolus during life the air was shown to be in the more superiorly located (right) pulmonary artery The patient recovered. In a similar case recorded by Hepper the patient died.

During Vascular Surgery.—A number of cases have occurred during arterial grafting several of which have been due to omitting to fill the graft with saline or heparin solution before releasing the clamps.

During Operations upon the Heart.—In operations within the open heart the dangerous moment when air embolism may occur is immediately after suture of the myocardial incision and the return of blood flow Air trapped in the heart is now propelled into the peripheral or pulmonary circulations. To obviate this ever-present danger Swan et al flood the thoracic cavity with Ringer's solution just before closure of the cardiac incisions, and suture the heart under water

During the Induction of a Pneumoperitoneum.—A large number of cases of air embolism have been reported during this procedure. The most frequent cause is puncture of the liver Less frequent causes are puncture of the spleen retroperitoneal emphysema, and intravascular injection in the abdominal wall. Twelve deaths from this cause occurred in a few years at the State Hospital of California (Dasher et al.) while 11 cases were reported from one hospital in Uruguay (Esperanza)

A man of 34 admitted to the Royal Northern Hospital with bilateral pulmonary tuberculosis underwent pneumoperitoneum to collapse both lungs. Two months later he attended for a refill. After 600 ml. of air had been injected, he complained of discomfort and breathing became difficult The needle was removed, he got off the operating table and walked into the passage, collapsed, and died. Necropsy showed a puncture of the liver within which there were large bubbles of air The right heart was filled with bloody froth.

In an almost similar case reported by Hollander on assuming the upright position the patient, a man of 56 fell down dead.

During Peritoneoscopy the number of reported cases are few which is what one would expect from this but little used method of examination.

During Abdominal Operations.—Fortunately the whole field of abdominal surgery is almost immune to the dangers of air embolism, although Rich encountered a case during the division of dense abdominal adhesions. No doubt the mechanism of air entry in this case was the same as that in thoracoplasty

During Lavage of a Maxillary Antrum.—Air embolism is a terrifying complication of lavage of a maxillary antrum. Usually it is due not to the lavage itself but to the insufflation of air that sometimes follows. The latter is not only exceedingly dangerous, but is unnecessary Pang collected reports of no less than 58 cases from this cause.

During Excision of the Upper Jaw.—Air embolism is a rare complication of this formidable operation.

During Operations on the Neck.—

a If, in the course of such operations as dissection of tuberculous or malignant cervical lymph nodes a ligature "blows off" during a fit of coughing (which unfortunately sometimes occurs when endotracheal anesthesia is allowed to become too light), air can be sucked into the jugular vein or one of its tributaries, unless digital pressure followed by gauze packing is forthcoming swiftly and dexterously and is maintained until the coughing has ceased.

b Air embolism is very rare during thyroidectomy Nevertheless, Guthrie and Evans were able to collect 15 hitherto unreported cases, and there are other reports of smaller collected series in the literature. As one can appreciate, the accident occurs more often during the removal of a retrosternal goitre

In Suicidal Cut throat.—The superficial veins of the neck are in many places attached to the deep fascia, and when they are severed this attachment prevents their collapse It is for this reason that air embolism is frequently the cause of death in suicidal cut throat.

During Radical Mastectomy.—In this instance air has entered the subclavian vein or one of its tributaries.

Obstetrical and Gynæcological Causes.—

a. During or soon after delivery per via naturalis or by Cæsarean section, if the placenta becomes displaced air can enter the open uteroplacental veins. In a series of 18 cases collected by Waldrop all were fatal.

b As a result of pervaginal douching during pregnancy —Scores of cases of air embolism, most of them fatal, have occurred from douching, usually with a Higginson's syringe, with or without intent to procure abortion. Air (as well as soap and water) is forced into the uterus, often by the patient herself After partial separation of the placenta the air enters the open veins of the endometrium.

c. During insufflation of the Fallopian tubes, and also during salpingography The latter however more usually causes oil (lipiodol) embolism

In Urological Surgery—A number of cases of air embolus have been reported :—

a. During aero-urethroscopy in the presence of urethral hæmorrhage The accident occurs almost always when the patient is under general anæsthesia. I have seen two fatal examples at necropsy In both urethroscopy was carried out under general anæsthesia, and in both the anæsthetist felt air bubbles passing along the jugular vein. On the other hand, in many hundreds of urethroscopies performed personally without anæsthesia, or under local anæsthetic, the accident has not occurred.

b During perirenal insufflation of air as opposed to oxygen, to delineate a renal or a suprarenal tumour

c. During aero-cystography a method which should now be obsolete.

In Neuro- and Orthopædic Surgery.—The sitting position used in neurosurgery and for the removal of prolapsed intervertebral disk predisposes to air embolism via the para vertebral venous plexus. Hanby and Terry encountered 6 cases during operations for excision of prolapsed disks in this position 5 were fatal.

Clinical Manifestations.—Occasionally the onset is insidious. Much more often it is abrupt, with deep inspirations, coughing expirations, cyanosis, then a few gasping breaths, succeeded by unconsciousness and cessation of respiration. The pulse becomes impercept ible, and the blood pressure falls to an unrecordable level A stethoscope applied to the precordium reveals the "mill wheel" murmur—a churning and splashing that masks the true heart-sounds. In not a few instances, if the pulps of the fingers are placed over a jugular vein, bubbles of air can be felt moving beneath. In about half the cases, especially those in which the head is higher than the trunk at the time of the entry of air the state of unconsciousness is preceded by tonic and clonic convulsions, followed by muscular twitching In venous air embolism the heart continues to beat long after the pulses are imperceptible.

In fatal cases the symptoms last less than one hour in 86 per cent, between one and twenty three hours in 7 per cent, and twenty three hours or more in 7 per cent whereas in non-fatal cases the symptoms last less than one hour in 9 per cent of cases, between one and twenty three hours in 48 per cent, and more than twenty three hours in 43 per cent.

In 20 unreported cases collected by Dasler et al the symptomatology was as follows :—

Falling pulse (weak or absent)	20	Convulsions	10
Unconsciousness	19	Restlessness	9
Cyanosis	18	Pupils dilated	8
Apnœa	14	Pain in the thorax	6
Dyspnœa	10	Incontinence	6

Mechanism.—

a. In the right auricle blood and air are churned into foam. The bloody foam fills the right auricle, passes on to distend the right ventricle, and causes an air lock between the latter and the mouth of the pulmonary artery. Whole blood is not compressible; air is compressible. Blood foam is sufficiently compressible during systole and expansile during diastole to prevent this chamber of the heart being emptied adequately; muscular contractions of the right heart compress the foam, instead of pumping blood into the pulmonary artery. In massive air embolus some of the bubbles escape into the pulmonary artery, and the arterioles of the lungs become packed with air locks, in which event a fatal issue from cyanosis and anoxia ensues quickly.

b. Large bubbles in veins on the way to the heart rise against the venous blood stream. If the head is higher than the trunk, these bubbles pass up the superior vena cava or, if the patient is coughing and straining, up the paravertebral venous plexus, which serves as a by-pass. In both instances air bubbles reach the brain.

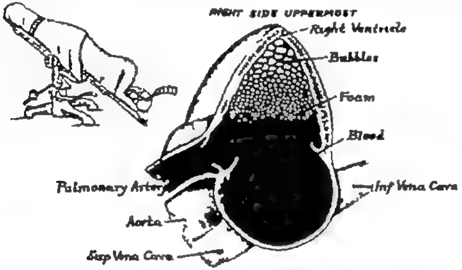


Fig. 146.—With the patient on his left side and tilted head downwards, air in the right side of the heart rises towards the apex.

Treatment.—To be successful, immediate action and sustained effort are imperative.

1. Tilt the patient so that the head is low. Large bubbles in the venous system then pass to the veins of the pelvis and the lower extremities, there to be absorbed in due course. The head-low position, if adopted rapidly, will prevent cerebral air embolism.

2. Turn the patient on to his left side, *i.e.*, with the right side uppermost. This must be accomplished within one minute of the onset of symptoms. Placing the patient on to the left side causes air in the right ventricle to rise towards its apex (*Fig.* 146), permitting whole blood to be pumped by the heart into the pulmonary artery.

3. Perform artificial respiration with the patient on his side. When the catastrophe occurs during an operation under general anæsthesia, the anæsthetist carries out controlled respirations by administration of pure oxygen under pressure, preferably, of course, via an endotracheal tube. When, as is often the case, an anæsthetist is not present, a free airway must be provided by, in order of preference, (1) pulling the tongue forward, (2) holding the jaw forward, and, when it is available, pure oxygen is administered by means of an anæsthetic mask, as above. In other circumstances artificial respiration is carried out with the patient lying on his left side, as shown in *Fig.* 147, which, contrary to what might be thought, is most efficient. It should be noted particularly that if efforts to maintain an unobstructed airway fail there should be no hesitation in performing *tracheotomy*. This was carried out in Musgrove and McQuigg's patient with striking benefit, and was undoubtedly the turning point of a successful issue. Even if there is a slight improvement, persevere with postural treatment and artificial respiration. Occasionally the patient must be kept in this position for hours, for when he is turned on to his back there is a recrudescence of symptoms. In one of A. C. Cohen's four successful cases recovery followed after eight hours of such treatment.

4 Inject the contents of an ampoule of 25 per cent nikethamide (coramine) intravenously

5. At a very early stage pass a wide bore needle in a proximal direction into the usually grossly distended external jugular vein on the right side, and aspirate Using this expedient, Bohn aspirated blood-stained froth, which brought about rapid improvement. His patient recovered.

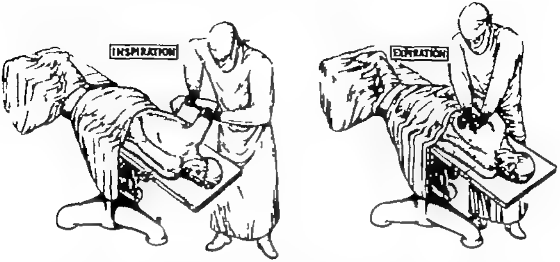


Fig 147—*Method of carrying out artificial respiration with the patient on his left side*

6. If this is unsuccessful, a lumbar puncture needle connected to a syringe is introduced into the right ventricle by piercing the skin beneath the left costal margin and directing the needle upwards and backwards. By this means it may be possible to aspirate the air from the right heart. Stallworth withdrew froth by this route and the patient recovered.

7 If after 2 min., or at the most 3 min. there are no signs of life, the patient must be turned on to his back and the heart exposed by an incision through the 5th left interspace The right ventricle can then be aspirated under vision, and, after discarding froth the blood is returned to the left ventricle. Massage the heart if necessary *but on no account commence cardiac massage until all the froth has been aspirated.*

ARTERIAL AIR EMBOLISM

In the case of air injected into the arterial tree or the pulmonary vein, the quantity required to produce death is but a fraction of that necessary to produce a similar catastrophe when introduced into the venous system.

Causes.—(*a*) When a bottle of blood has been permitted to empty completely during retrograde arterial transfusion (*b*) When air is sucked into a pulmonary vein or one of its tributaries during an operation on the thorax (*c*) Occasionally when air is injected into one of the tributaries of the pulmonary vein during the induction of a pneumothorax.

Clinical Manifestations.—The onset is more catastrophic than venous air embolism. If the patient is conscious, he feels faint or dizzy Following these warnings there is loss of consciousness some regain consciousness, but are disorientated. Cyanosis is present almost invariably Convulsions, localized or generalized, tonic or clonic, often occur Nearly always the pupils become dilated widely The patient becomes almost or completely pulseless. *The mill wheel murmur is not present* As a rule there is slowing of the rate of respiration sometimes it is of the Cheyne-Stokes variety Should the patient be so fortunate as to recover from the acute episode precordial pain accompanied by considerable dyspnoea lasts for hours, or sometimes days. Various neurological manifestations, including hemiplegia, monoplegia, nystagmus, strabismus, and sometimes blindness, are not infrequent aftermaths.

Pathognomonic Signs.—

Marbling of the skin of the superior part of the body has often been noted. It is due to embolism of the skin vessels.

Leibermeister's sign: There is pallor of half or a portion of the tongue depending upon which lingual artery or portion thereof is blocked. This sign is said to be very constant but it is often missed because of the anxiety that prevails.

Air bleeding If a small incision is made into the skin of the upper part of the body air bubbles are observed in the blood that escapes.

Bubbles of air have been observed streaming through the retinal vessels by ophthalmoscopic examination, which is seldom practicable.

Mechanism.—When air enters the left ventricle three possibilities have to be considered —

1 Air enters and occludes the coronary arteries. This may lead to almost instantaneous death.

2. A bolus of air in the left ventricle preventing the delivery of blood to and from this chamber

3. Cerebral air embolism. The lumina of the tortuous cerebral arteries are sites *par excellence* for the arrest of itinerant arterial air emboli.

Treatment.—

1 Tilt the patient so that the head is low

2. Turn him on to his left side It is more advantageous to turn him still farther—into the half prone position—and hold him there In this position the mouths of the coronary arteries are dependent (*Fig* 148)

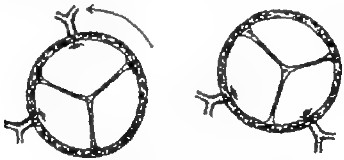


Fig 148 —With the mouths of the coronary arteries dependent, air cannot enter them.

3. Pure oxygen should be administered and artificial respiration carried out.

4 Should these measures fail, after two to three minutes trial there is only one possible life-saving expedient—that is to expose the heart and aspirate foam from the left ventricle. If there is not sufficient blood to inject after the foam has been discarded procure more blood by aspirating the right ventricle Inject the contents of the syringe into the left ventricle and carry out cardiac massage

* * * * * *

When confronted with a case of air embolism, it should be almost a reflex act to place the patient in the head-low right-side uppermost position. Without a theoretical knowledge of what to do when faced with this emergency the chances of saving the patient's life are almost negligible

REFERENCE

BAILEY HAMILTON *J int Coll Surg*., 1936, 25, 675 for further references.

CHAPTER XI

ACUTE NON-SPECIFIC INFECTIONS

THROUGHOUT this book, when antibiotic treatment is indicated, directions are given as to which antibiotic or combination of antibiotics is recommended together with, in many instances, the dosage. Before discussing the subject of acute non-specific infections—conditions in which antibiotic therapy plays so large a part—it is thought advisable to make some statements that hold good for antibiotic therapy in general.

Antibiotics are divided into two classes —

Group 1 (bactericidal): penicillin, streptomycin, erythromycin, the polymyxins.

Group 2 (bacteriostatic): chlortetracycline (aureomycin), chloramphenicol, oxytetracycline (terramycin), tetracycline (achromycin).

Combinations within group 1 are often synergic; within group 2 they are merely additive. Combinations of the two groups, however, are apt to be antagonistic, the group 2 antibiotics interfering with the action of group 1 antibiotics. Such antagonism is observed only when the organism is fully sensitive to the bactericidal component; when it is more resistant the combination may prove to be synergic (L. P. Garrod).

Intolerance and Toxic Reactions following the administration of antibiotics.—Although the complications arising from the employment of antibiotics are small in comparison with the benefits they confer, every antibiotic carries with its use possible complications which should be known to the prescriber.

Penicillin.—No antibiotic so visibly demonstrates untoward reactions as does penicillin, the ill effects taking the form of dermatological reactions, serum sickness, and anaphylactic shock (*see* p. 79).

So many persons have received penicillin, and some of them have become sensitized, that before commencing a course of injections of this antibiotic not only should inquiries be made as to whether the patient has received this drug on a previous occasion, but there should be in readiness a syringe containing 0·3 ml. of 1–2000 adrenaline hydrochloride so that its contents can be injected intramuscularly without delay should untoward symptoms arise.

Serious symptoms are liable to follow the accidental injection of penicillin into a vein, in which event there is a feeling of impending death and acute mental anxiety without respiratory or cardiac embarrassment. Every time penicillin is injected, care should be taken, by attempting preliminary aspiration, to ensure that the tip of the needle is not within a blood vessel.

Urticarial skin eruptions can occur early or late in the course of penicillin administration. They are controlled by the prompt administration of one of the antihistamines, e.g., one 50-mg. benadryl capsule three or four times a day.

Streptomycin.—The main toxic manifestation is damage to the vestibular division of the 8th cranial nerve, the symptom of which is vertigo. Cochlear damage causing deafness and tinnitus, is much less common. In order to obviate these dangers streptomycin should not be continued for more than 12 days without an interval of at least three weeks unless there is an adequate reason for breaking this rule, e.g., tuberculosis. Streptomycin must never be given in the presence of impaired renal function, because it is not excreted; vestibular damage can result from one injection (T. Cawthorne).

The Tetracycline Group.—Chlortetracycline (aureomycin), oxytetracycline (terramycin) or tetracycline (achromycin) should always be given in conjunction with vitamin-B complex tablets, because antibiotics of this group create a lack of this vitamin complex.[1] The highest incidence of untoward reactions occurring with the use of these broad-spectrum antibiotics is associated with aureomycin. While comparatively minor reactions consist in stomatitis, sore throat, and anorexia, the one always to be feared is acute staphylococcal enterocolitis.

[1] By killing Gram-negative organisms normally present in the intestine. These organisms produce a large quantity of vitamin B, which is utilized by the host.

Acute Enterocolitis during Antibiotic Therapy (syn. Pseudomembranous enterocolitis; Staphylococcal cholera).—Although uncommon, pseudomembranous enterocolitis arising as a direct result of antibiotic therapy has occurred and is occurring sufficiently frequently to warrant considerable alarm. Most often it has arisen in the early post-operative period following an abdominal operation, and the patient has received a broad-spectrum antibiotic, but it is evident that the condition can occur after any operation, or indeed when no operation has been performed, and when the antibiotic therapy has consisted of penicillin and streptomycin, or even when sulpha drugs such as sulphaguanidine or sulphasuccidine have been employed to sterilize the intestinal tract. The enterocolitis is caused by *Staph. aureus* resistant to the antibiotic or antibiotics administered.

Staph. aureus does not establish itself in an intestinal tract containing the usual bacterial flora, notably *Esch. coli*, but when, as a result of antibiotic therapy, the microbic population of the alimentary canal has become sparse or absent, resistant staphylococci introduced in contaminated food take up their abode in the intestinal canal and multiply with extraordinary rapidity.

Infrequent vomiting and profuse diarrhœa are the leading symptoms. In fulminating cases the diarrhœa is so copious as to have earned the condition the name of staphylococcal cholera. The infection is usually accompanied by profound toxæmia, producing a shock-like state. There is strong evidence to support the contention that the shock is caused by the staphylococcal enterotoxin. Incorrectly treated, and too often in spite of correct treatment, within 24 hours the patient passes into semi-coma, accompanied by cyanosis and dyspnœa.

The only method of confirming the diagnosis is by finding the stools teeming with *Staph. aureus*. Until recently sometimes bacteriological confirmation was lacking because many bacteriologists did not regard *Staph. aureus* in the stools as pathogenic, or culture had not been made on blood-agar, the only reliable medium in this instance. *A direct smear of the anal discharge should be made in every suspected case* while culture and other time-consuming bacteriological examinations take their normal course. The diagnosis of staphylococcal cholera is, therefore, not difficult; this cannot be said of two rarer forms of the disease:—

1. *Ileus type* is characterized by increasing abdominal distension which does not respond to gastro-intestinal aspiration. Diarrhœa is not often present.

2. *Precipitous shock type*. The shock comes on so rapidly and so profoundly that it clouds the diagnostic horizon.

Treatment.—Intravenous fluid replacement must be commensurate with the intestinal loss of fluid. Spectacular recovery has followed the administration of corticotropin; some of the patients have been on the brink of death, and following one or two injections have so improved within a few hours as to appear out of immediate danger (van Prohaska). Without this treatment the mortality is over 70 per cent.

Erythromycin is designated as the antibiotic with a specific action against *Staph. aureus*. Unquestionably it should be administered without delay. Even if it is specific for the particular strain of *Staph. aureus*, its action is too slow to save many patients. While erythromycin is extremely potent against *Staph. aureus* at the time of writing some staphylococci are becoming erythromycin resistant, and in the not too distant future this antibiotic rampart, like the others, may crumble.

As a corollary arising out of this account of pseudomembranous entero-colitis occurring during antibiotic therapy, the surgeon should question himself: Am I justified in permitting myself and my juniors to prescribe 'umbrella' antibiotic therapy after operations? Decidedly the answer is 'No': such therapy flirts with a serious and often fatal complication. Antibiotic therapy should be given only if there is a definite infection to combat.

SEPTICÆMIA

Essentially, septicæmia is of two varieties: that due to Gram-positive bacteria and that due to Gram-negative bacteria. In the former the causative organism is usually either a streptococcus or a staphylococcus. Probably the relative frequency of staphylococcal as compared with streptococcal septicæmia has increased; certainly that due to penicillin-resistant staphylococci has become more frequent.

What is not well known is that approximately 50 per cent of the cases of septicæmia occurring in surgical practice are due to Gram-negative bacilli of the coliform, pseudomonas and proteus groups.

The diagnosis of septicæmia can be made with certainty only by bacteriological culture of the blood. For this purpose at least 10 ml. of venous blood placed in a sterile bottle containing citrate solution is required, and rigorous aseptic technique is essential to exclude contaminants. Preferably the blood should be withdrawn soon after the patient has had a rigor. To be enabled to make an undeniable diagnosis of septicæmia it is necessary to receive a positive blood-culture report on more than one occasion. It is just possible that an individual positive blood-culture might be due to a transient bacteræmia.

The portal of entry is, in the case of *Gram-positive bacteria*, sometimes through a minute cutaneous lesion difficult or impossible to find, sometimes through an obvious open lesion (not forgetting the placental site), and sometimes from a deep-seated abscess perhaps undiagnosed because the symptoms have been masked by antibiotic therapy.

In most cases of septicæmia due to *Gram-negative bacteria* the portal of entry is well defined. In 50 per cent of cases infection occurs via the genito-urinary tract, chief among the causative lesions is pyelonephritis, sometimes following unsterile catheterization or transurethral resection of the prostate. Cystography and retrograde pyelography in the presence of infected urine also add their toll. The next most common avenue is the female generative tract, notably in endeavouring to induce abortion by intra-uterine douching. The third most common portal of entry is the biliary system (cholangitis secondary to a stone impacted in the common bile-duct and empyema of the gall-bladder).

Although admittedly infrequent, nearly every large series of cases of septicæmia include one, or perhaps two, tragic instances where infection has been introduced by transfusion of contaminated blood; occasionally the organisms are introduced, not with blood, but with other forms of intravenous fluid therapy, while the most recent addition to this intensely worrying group of cases is incompletely sterilized polythene tubing.

Clinical Features.—The febrile response is variable, but 75 per cent of patients with septicæmia have one or more rigors a day. As is well known, the temperature is usually hectic; less often it is sustained for days. In cases where the patient's resistance to the bacterial onslaught is feeble, cutaneous petechial hæmorrhages sometimes appear, and are usually a harbinger of death.

Shock accompanying septicæmia occurs more often when septicæmia is caused by Gram-negative bacilli than when the organism is Gram-positive. The onset of the peripheral circulatory impairment is nearly always abrupt, and comes on soon after a rigor. Following the rigor, and preceding the shock, is a sharp rise in temperature. The duration of the hypotension varies from many hours to many days. In 58 per cent of cases the skin is pale, cold and clammy, and the pulse is weak and usually fast. In 42 per cent the skin is warm, dry, and often flushed, and the pulse is bounding and not unduly rapid. Those of the second group who do not receive, or do not respond to, measures to combat shock, pass into the more typical state of the first group. Half the patients who develop this complication do not respond to anti-shock treatment, and death occurs, often in a matter of hours.

The probable explanation of the phenomenon of shock arising so suddenly in the course of septicæmia is what may be termed a therapeutic paradox, caused by the killing (by antibiotic therapy) of myriads of bacteria, which in death release their endotoxin. Having regard to this supremely dangerous complication, especially in cases of Gram-negative septicæmia, it is probably best to give increasing doses of the chosen antibiotic rather than to give a massive dose as soon as the diagnosis is made.

Treatment.—

Antibiotic Therapy.—There is no condition in which the bacteriologist (after he has been given time to make the necessary sensitivity tests) plays a greater part in therapeutic guidance as to which antibiotic should be selected. While awaiting this invaluable information it is usually best to commence treatment with combined penicillin 500 000 units, and streptomycin 0·5 G. 12-hourly. When there are adequate reasons for suspecting that the septicæmia is staphylococcal, it is probably wise to assume, for the time being, that the organism is not fully penicillin-sensitive, and to give terramycin, 500 mg. 6-hourly.

If a Gram-negative infection seems probable, one should, for reasons given, step up the dosage rather than commence with what is considered to be a "really effective" dose. *Esch. coli* and the paracolon bacillus are more sensitive to antibiotic therapy than any other Gram-negative organism, and chloramphenicol inhibits more organisms of the Gram-negative group than any other antibiotic. 50 per cent of proteus infections are found to

be sensitive to chloramphenicol. Polymyxin is found to be the best antibiotic to employ in cases due to *Ps. aeruginosa* which is often resistant to treatment; half the strains are also sensitive to sulphonamides.

General Measures.—Watch must be kept for early signs of concomitant shock, especially after the first dose of antibiotic and in the period immediately following a rigor. The only safe guides to the early diagnosis of shock are a 2-hourly pulse chart and a record of the blood-pressure, especially following rigors.

While all operative measures should be postponed until an attempt has been made to get the infection under control, it is equally important not to overlook an empyema of the gall-bladder, a pyonephrosis, a subdiaphragmatic abscess, or metritis following an unreported abortion. Each of these conditions must be excluded by all the diagnostic means at one's disposal, and should one be present the simplest operation that will mitigate renewed infection of the blood-stream is undertaken. Metastatic abscesses must also be drained. The progress of the case is watched by daily blood-cultures, leucocyte counts, and hæmoglobin estimations. When even slight anæmia ensues, the patient is likely to benefit from blood transfusion, if necessary repeated.

LYMPHANGITIS

Red lines are seen coursing up the limb (*Fig.* 149). Lymphangitis can be a dangerous condition. Occasionally it passes dramatically on to septicæmia which, if not recognized

Fig. 149.—Acute lymphangitis with subcutaneous cellulitis over the inguinal lymph-nodes.

and treated promptly, can result in death in a remarkably short time. Particularly serious is the lymphangitis which follows abrasions or pricks received in the post-mortem room or at operations on infected conditions. The temperature chart here shown (*Fig.* 150) illustrates a case of galloping septicæmia, seen in the days before antibiotics. The patient was admitted with a scratch on the foot with lymphangitis. In two days she was dead. Fortunately such examples are uncommon.

The patient should be ordered to bed in a side-room. Local treatment is unnecessary except to prevent cross-infection. For that purpose alone the affected parts are mopped once with a 1 per cent solution of cetavlon, and covered with a bandage. Because lymphangitis is nearly always due to a hæmolytic streptococcus or a staphylococcus, penicillin is administered forthwith in doses of 500,000 units 12-hourly. The results are among the most spectacular in surgery. Should the patient be allergic to the drug, or if there is any question of the presence of penicillin-resistant strains, employ achromycin in doses of 250 mg. 4-hourly by mouth and continue it for two days after the temperature has subsided. A watch must be kept on the regional lymphatic nodes. When they are

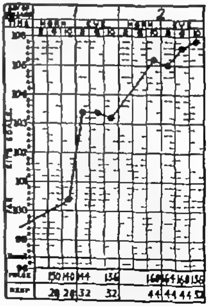


Fig. 150.—Case of lymphangitis, secondary to an infected scratch, which was seen prior to the isolation of penicillin. Galloping fatal septicæmia resulted.

enlarged and tender abscess formation might follow insidiously—even more insidiously under an antibiotic régime.

SUBCUTANEOUS CELLULITIS

It should be noted that these remarks apply to *subcutaneous* cellulitis. Cellulitis of a closed fascial space may require early surgical intervention, as has been pointed out in the sections dealing with Ludwig's angina (p. 844), extravasation of urine (p. 974) and infection of the fascial spaces of the hand (p. 1014).

The following account refers particularly to subcutaneous cellulitis of a limb, and more especially to cellulitis following a small abrasion, or where there is no demonstrable lesion.

1. Accurate recognition is essential. Subcutaneous cellulitis can be a dangerous diagnosis, especially in children, in whom an underlying bone condition must always be excluded. Clostridial infections are occasionally subcutaneous: they then form a special and important class—*anaerobic cellulitis* (Fig. 151). This should constantly be borne in

Fig. 151.—Extensive anaerobic cellulitis of the forearm treated by tetracycline 2 G. per day given by mouth in four equally-divided doses for four days, followed by 1.5 G. per day for three days. (*Pulaski and Beatty.*)

mind when a crepitant superficial inflammation follows penetrating wounds (muscle damage and the introduction of foreign bodies) or when such a cellulitis supervenes upon an already existent diabetic gangrene (see p. 963).

2. As Gram-positive pyogenic cocci are by far the commonest cause of cellulitis, prescribe penicillin systemically 500 000 units 12-hourly. This forms the sheet anchor of rational therapy in the great majority of instances.

3. Secure rest for the inflamed part. This usually entails ordering the patient to bed and placing the affected limb in an elevated position on a splint or, better still, on a plaster of Paris slab.

4. Local applications such as fomentations, ichthyol, and so on, although comforting to the patient, are of no value and often mask physical signs.

Fig. 152.—Needle aspiration of the exudate was followed by resolution. The olecranon bursitis shown required separate aspiration. (*Pulaski and Beatty.*)

5. With proper rest and an early resort to the specific antibiotic, pain soon lessens and the whole of the cellulitis frequently resolves. Sometimes the suppuration becomes confined to a localized area which requires drainage, but not too early. In cases without an obvious focus, when the inflammatory reaction has subsided one sometimes finds that the suppurative process is connected with, for example, a prepatellar or an olecranon bursa which was previously obscured by oedema.

6. Only when there is convincing evidence of a localized soft abscess does the need for operation arise. If in any doubt, it is far wiser to pursue a conservative course. The incision rarely more than 2 cm. in length is made at the site of maximum fluctuation and the purulent collection drained with corrugated rubber. When a really large area of subcutaneous tissue becomes filled with pus, it is necessary to make more than one opening and to design the incisions so that they lie at the most dependent points in order to favour drainage. If, as is sometimes the case, preliminary aspiration yields semipurulent fluid, complete aspiration, replacement of the fluid withdrawn by a solution of the chosen antibiotic, followed by a firm bandage is sometimes all that is necessary (*Fig.* 152).

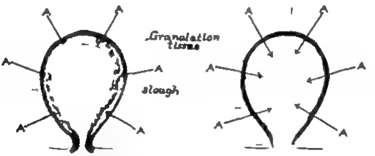
7. In no circumstances whatsoever is it necessary to make multiple incisions into inflamed œdematous tissue. Usually no pus is found. The incisions reveal œdema of the subcutaneous spaces, and a little watery fluid escapes. This untimely surgery often incites the *inflammatory process to greater activity*.

Cellulitis of the Abdominal Wall.—(*See* p. 177.)

TREATMENT OF ACUTE ABSCESSES IN GENERAL

Methods of dealing with special abscesses, e.g. subdiaphragmatic, ischiorectal, periurethral, etc., will be found in the appropriate sections. These remarks refer particularly to miscellaneous abscesses which are commonly encountered.

As a rule, to await the advent of fluctuation is to wait too long. As soon as pus has made its appearance manifest by softening or bogginess in an area of induration or, in some situations, by œdema of the overlying skin, no time must be lost in giving it exit. Those who wait for an abscess to point have allowed the subcutaneous tissue in the immediate vicinity of the area in question to become involved, and an incision at this stage is often followed by necrosis of the edges of the wound. It is for this reason[1] that operation is advised before pointing is allowed to occur. Cultures made from pus obtained by incision



I II

Fig. 152.—I. Abscess treated by simple incision. Antibiotic (A) cannot penetrate the granulation-tissue-cum-slough barrier. II. Abscess treated by incision plus abrasion of the granulation tissue lining the cavity. Antibiotic (A) from the blood-stream enters the cavity.

of non tuberculous closed abscesses unconnected with the intestine show that over 95 per cent are due to staphylococci, streptococci, or both. On the other hand, if through necrosis of the overlying skin a granulating wound is established, whether this occurs spontaneously or as a result of incision after waiting too long, secondary infection by coliform and other Gram-negative organisms, such as *Esch. coli* and *Ps. aeruginosa* often occurs. That is why penicillin is frequently wasted when it is given in this type of case (Lowden).

Once pus has formed it is useless and dangerous to rely on antibiotics alone. "Where there is pus, let it out" is still the order of the day, but under systemic antibiotic cover, mere incision and drainage is, with notable exceptions, insufficient, as will be explained immediately.

Surgical Pathology.—An abscess increases in size in the following way: the innermost layer is killed by bacteria, while the outermost layer (provided the combined natural and acquired resistance of the host is adequate) becomes strengthened. *As a rule the granulation tissue lining the walls of the cavity increases in thickness pari passu* with the process of liquefaction. It is true that this lining is the chief barrier to bacterial onslaught, thrombophlebitis, and septicæmia. *It is equally certain that, because of this barrier*, but

[1] Another reason for opening an abscess is pain. If the answer to the question, Did you sleep well last night? is in the negative, and the reason for it was pain, the abscess should be opened.

little circulating antibiotic can reach the abscess cavity and none can enter when the inner layer has become a slough slough is completely avascular (*Fig* 153).

When, and When not, to remove the Lining Membrane (Granulation Tissue).—Removal of that part of the lining membrane that comes away easily is not new in the nineties Sir Frederick Treves advocated such a procedure as part of the operative treatment of a psoas abscess. At the present time, from the point of view of treatment, abscesses can be divided into —

1 *Those where the Lining Membrane must be left undisturbed.*—These comprise: (*a*) abscesses that are situated in juxtaposition to named blood vessels and (*b*) abscesses in the immediate vicinity of intestine.

2 *Those where There is No Contra-indication to removing the Lining Membrane.*—The great majority of abscesses belong to this category

A safe method of effecting the removal which, as will be shown, must be carried out under a high concentration of circulating antibiotic, is to wipe away the granulation tissue with a finger covered by two layers of gauze or when the opening is of necessity too small to admit a finger by the very gentle use of a curette.

PRINCIPLES IN OPERATING UPON AN ABSCESS

Anæsthesia.—It is a mistake to operate under a very short general anæsthetic the operator must not feel hurried, and in many situations proper muscular relaxation is essential.

Pre-operative Antibiotic Therapy—Three-quarters of an hour before the operation 000 000 units of procaine benzyl penicillin in aqueous suspension and 200,000 units of aqueous penicillin are given intramuscularly with the premedication for the anæsthetic. If it is suspected that the infection is caused by Gram negative as well as Gram-positive organisms, 0·5 G of streptomycin is administered also.

Obtaining a Specimen for Bacteriological Examination.—Before commencing the operation *it is extremely important to have in readiness a sterile test-tube so that a sample of pus can be collected for bacteriological examination, including sensitivity of the causative bacteria to antibiotics.*

TECHNIQUE

Aseptic precautions must be as perfect as in a clean case. A scalpel with a standard blade is employed except for superficial abscesses, when one with a fine-pointed blade is used in the manner depicted in *Fig* 154 Usually the incision follows Langer's lines or when present, skin creases, but in the case of a deep-seated abscess situated in relation to important blood vessels or nerves, the incision should lie parallel to and not across, the direction of the structures which it is desired to avoid.

Fig 154 —Method of opening a per ficial abscess.

Hilton's Method.—*If important structures are likely* to be encountered or injured, Hilton's method should be employed. This consists in incising the tissues down to the deep fascia and inserting a blunt-ended grooved director (*Fig* 155) into the most prominent part of the swelling or where with a finger in the wound, softening is most obvious, until pus flows along the groove. Guided by the director a hæmostat is passed into the cavity its jaws are opened, and with the jaws still open the hæmostat is removed thereby enlarging the opening

Fig. 155.—Blunt-ended grooved director (Allen & Hanburys)

Standard Procedure.—*In most situations the incision can be deepened with the scalpel* until the abscess is opened, or deepened until it is judged that the wall of the abscess has been reached, and then plunging a closed hæmostat into the cavity The incision should be large enough to admit the index finger easily or at any rate the little finger A finger is introduced (*Fig* 156) and all loculi are broken down so as to ensure that there is one cavity and one cavity only Unless there is a contra indication for so doing, the lining membrane of granulation tissue is then abraded in the manner described already

Primary Suture.—Although much discretion is required, provided the patient's general symptoms are mild and the abscess is situated where the cavity can be obliterated by a compression dressing a number of surgeons recommend primary suture with the main object of preventing secondary infection. Even if some blood-clot has to be evacuated at the first dressing, healing proceeds apace.

Drainage.—As a rule when drainage is deemed necessary a soft rubber tube of fair size is employed. Should the location of the abscess be unsuitable for a drainage tube e.g., it might cause pressure necrosis of an artery corrugated rubber or a piece of rubber glove is substituted.

A Counter-opening.—Often an abscess must be opened towards its centre, but sometimes this is not the site for dependent drainage. This may necessitate making a counter-opening by passing a hæmostat to the most dependent part of the cavity opening the blades slightly and holding them so that the tips can be felt through the skin cutting between them. After a drainage tube has been inserted and anchored, the primary incision is closed. Unless there is some definite reason for not so doing drainage material should be removed on the second, or at the latest, on the third day after its insertion.

Fig. 156.—The little finger is introduced into the abscess cavity and is used to explore and when necessary break down loculi.

The Closed Method.—When the overlying skin is involved, excellent results follow comparatively wide excision of the involved skin. Having removed the lining of granulation tissue, the abscess cavity is packed with petroleum jelly gauze, the area being encased preferably in a viscopaste bandage or when this is impracticable covered by strips of flexible adhesive plaster (*Fig* 157). This principle of treatment gives better and quicker healing than that obtained by bottle-neck drainage (*Fig* 158) with necrosis of the edges of the skin wound. There is seldom any need to disturb the dressing for a week, when fresh packing should be inserted, not in the ward, but in the operating theatre. The cavity soon fills in with healthy granulation tissue and, contrary to expectation, skin grafting is rarely necessary.

Fig. 157.—Treatment of an abscess by excision of overlying skin and packing abscess cavity

Fig 158.—Bottle-neck tube drainage

Rest.—Whatever principle of operative treatment is employed rest of the part concerned is a handmaiden that expedites healing. Neglect of this detail is a cause of a troublesome sinus. Whenever possible the part should be immobilized by a bandage or a splint, a plaster slab being admirable where applicable.

ABSCESS OF THE BREAST

The highest incidence of acute mastitis is during the second week of the puerperium a few cases occur before that time but many are encountered when breast feeding has been prolonged unduly often in the mistaken belief that continued lactation militates against conception. The predominating organism is the *Staphylococcus aureus*

Penicillin therapy [1] combined with support to the breast with a firm many tailed bandage over wool if instituted early relieves the pain remarkably and brings about resolution in not a few cases. On the other hand, the prolonged use of penicillin after pus has formed leads to an increase in the surrounding induration and the production of a thick abscess wall that bleeds profusely when the abscess is incised, and delays healing. Therefore the breast must be examined daily after the milk has been expressed (*See* Indications for Operation *below*)

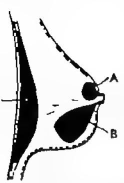


Fig 159 —Varieties of abscess of the breast A, Subareolar; B, Intramammary; C, Retromammary

To Wean or not to Wean is a question of great importance. Except when the patient has been suckling the child for over nine months, undoubtedly it is better not to wean Feeding is continued from the uninfected breast, and the infected breast is emptied after each feed by manual expression, carried out by the patient herself this is more effective than a breast pump, which does not always clear obstructed ducts. The milk expressed from the inflamed breast is boiled for five minutes before being given to the child in a feeding bottle. In patients with bilateral acute mastitis the baby can be fed entirely on the milk obtained by expression after it has been boiled this is not detrimental to the child (Walsh).

Fig 160.—Incision exactly at the areolar margin.

In patients who have been suckling the child too long, weaning is advisable. A single dose of hexœstrol dipropionate 12 5 mg given intramuscularly after the breasts have been emptied, usually inhibits lactation completely occasionally a second dose is required.

Indications for Operation.—The breast should be incised when, after emptying an area of tense induration is felt and/or when some œdema of the overlying skin is found. Usually the area of induration is sector-shaped, and in early cases about one-quarter of the breast is involved In many later cases the area is more extensive Too often the creditable aphorism that it is better to incise an abscess of the breast (*Fig* 159) one day too late than one day too early is abused while the breast becomes riddled with extensions from the original abscess.

Incision.—Since a neglected breast abscess tends to point at the areolar margin, or close to it, it is better to incise here (*Fig* 160) rather than in the classical manner radiating from the nipple. An incision following the cutaneo-areolar margin has also a high cosmetic value The incision passes through the skin and the superficial fascia. A long hæmostat is then driven into the abscess cavity Every part of the abscess is palpated against the point of the hæmostat, and its jaws are opened (*Fig* 161) All loculi and lactoceles that can be felt are entered. Finally the hæmostat having been withdrawn, a finger is introduced and any remaining septa are disrupted. A drainage tube is inserted for 24 hours, and a dry dressing applied. In the case of a large abscess cavity especially if it is occupying a lower quadrant of the breast, it is necessary to make a counter incision at the most dependent part, and through this place the drainage tube. In this instance the primary incision can be sutured.

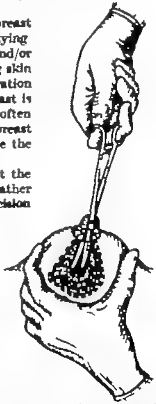


Fig. 161 —*Every part of the abscess should be palpated against the point of the hæmostat, and all loculi are entered and septa broken down.*

After treatment.—Expression of milk is continued, as also is penicillin therapy unless the organism is penicillin-resistant. In Canada several outbreaks of puerperal mastitis due to penicillin-resistant strains of staphylococci have occurred in maternity hospitals (Webb). Similar outbreaks have been reported from Norway In such cases another antibiotic should be substituted as soon as penicillin insensitivity is suspected.

[1] So common has infection by a penicillin-resistant staphylococcus become that it is wise to start treatment with another antibiotic

Subareolar Abscess shows a remarkable tendency to resist treatment, and to recur. If the infection is in a milk duct the dilated ampulla with its narrow duct, is likely to harbour organisms. In no less than 75 per cent of 64 patients with subareolar abscess studied by Kilgore and Fleming, recurrence or chronic sinus developed after the abscess had been opened or had burst spontaneously. Antibiotic therapy and irradiation were found to be ineffective. The most successful treatment was wide excision of the scar tissue and the underlying abscess cavity. In 9 instances repeated ineffectual operations had so deformed the breast that simple mastectomy was carried out.

Retromammary Abscess is rare and when it occurs it is a chronic abscess, often due to tuberculosis of a rib or to an empyema necessitans. It is best evacuated by a large incision following the inferior junction of the breast with the thoracic wall similar to that used for submammary excision of the breast. In this way the underlying pathology can be displayed and dealt with as necessary.

AXILLARY ABSCESS

The majority of axillary abscesses are secondary to infection of hair follicles or sweat glands of the axilla. A rather frequent cause in females is the use of a chemical depilatory. The minority are due to suppurative axillary lymphadenitis. Although it is common for the ymph-nodes to become enlarged secondary to infections of the hand, because of antibiotic herapy for the primary lesion it is unusual for the adenitis to proceed to pus formation.

Abscesses of the axilla must be opened promptly for the pus tends to extend along e path of the nerve-trunks into the neck. The site of the incision will depend upon the uation of the pus. *In acute abscesses pus usually lies under the pectoralis major.*

Fully abduct the arm. Make an incision quite 1 in (2.5 cm.) long just below the fold of the pectoralis major (*Fig* 162).

Fig 162.—Opening a deep-seated axillary abscess.

Fig. 163.—Under water tube for draining a large abscess. This principle can be applied to large abscesses in other situations. (*After G. P. Cassie.*)

Hilton's Directions for opening a Deep Abscess in the trilla.—Cut through the skin, cellular tissue, and fascia of e axilla about half an inch behind the axillary edge of e great pectoral muscle. At that part we meet with no large blood vessel. Then push a grooved director upwards into the swelling in the axilla. If you watch the groove in the director a little stream of pus will show itself. Take a blunt pair of forceps and run the closed blades along the groove in the director into the swelling. Now open the handles and so tear open the abscess parallel to important structures.

If the region of the axillary vessels is avoided studiously there is no objection to abrading the granulation tissue lining the major portion of the cavity.

In late cases, when the whole axilla is merely a bag of pus, an incision into the lower part of the middle of the space will be found convenient. In such circumstances a good means of drainage is the negative pressure method. After the pus has been evacuated

one end of a piece of rubber tubing 2½ ft. (75 cm.) long, with the lumen as wide as a cigarette, is introduced through the incision, which is closed tightly around the tube. The tube is anchored to the skin by a stout suture. After expressing blood and pus, and applying a pressure dressing, the distal end of the tube is clamped with a hæmostat. When the patient has been returned to bed the tubing is connected to an under water tube with a glass connexion (*Fig.* 103). Air is aspirated from the tubing by a needle and syringe until water rises as far as the glass connexion. Removal of air is repeated as often as necessary to restore the water to this level, thus enabling negative pressure to exert steady suction.

Stitch Abscess.—(*See* p. 152.)

SUPPURATING LYMPH NODES OF THE GROIN (syn. BUBO)

Either or both the groups of lymph-nodes situated beneath the inguinal ligament and along the common femoral vessels may be affected. The exciting causes are various. In children an infected blister of the heel or an inflamed scratch of the leg often produces suppuration in the femoral group of lymph-nodes.

Fig. 104.—Granuloma inguinale. Frei's test positive.

In adults, other causes of buboes are lymphogranuloma inguinale and soft chancres. In coloured races lymphogranuloma inguinale is especially common; it is far from rare in white races. Frei's test (*Fig.* 104) is extremely accurate in clinching the diagnosis. It should be remembered that penicillin is but slightly effective in this condition, streptomycin is without value, but aureomycin (250 mg. four times a day) is most effective. These buboes are almost always abscesses *around* the lymph nodes, which run a subacute burrowing course.

Because of their tendency to form long fistulous tracks in the cellular tissues, buboes should always be opened early under antibiotic cover. Having great regard for the femoral artery and vein, a vertical incision is made, and the abscess cavity kept open so that it may heal from the bottom. Many buboes, particularly those associated with soft sores, run such a chronic course that some surgeons prefer to dissect out the affected lymph-nodes. After the lymph nodes have been removed, every bleeding point, and every lymphatic vessel, is ligated. The wound is closed without drainage and firm pressure applied by means of strips of flexible adhesive plaster over dry gauze.

POPLITEAL ABSCESS

Arises most commonly from an infection of the lymph nodes of the popliteal space via lymphatics, from a sore on the heel. In this situation fluctuation occurs late, and one may be tempted to delay exploration of the indurated area. The result of undue delay can be crippling.

An adequate incision is made on the lateral aspect of the space parallel to the tendon of the biceps (*Fig.* 105). Pus is evacuated and the space drained by a corrugated rubber strip; a rigid rubber tube should not be used in this situation.

Fig. 105.—Incision for opening a popliteal abscess.

ANTIBIOTIC MODIFICATION OF ACUTE ABSCESSES

Modern methods have indeed revolutionized the treatment of abscesses. In so doing they have profoundly altered many time-honoured aspects of suppuration :—

a. The 'cold' abscess was once an almost infallible sign that the abscess was tuberculous. After a few days of pre-operative antibiotic therapy even a florid infection can result in an abscess which is not only 'cold' but bacteriologically sterile.

b. Sterile pus, like sterile pyuria, might still indicate tuberculosis, but nowadays it is much more frequently the result of a common pyogenic condition treated by the correct remedy. It is therefore important that information regarding the antibiotics a patient has received before admission should be forthcoming, and that when sending pus to the laboratory the pathologist should be informed of the therapeutic facts.

absence local and general ultra violet light is a good substitute. Such are the methods of building up the patient s resistance

Toilet of Surrounding Skin.—*If the surrounding area is hairy* wide atraumatic shaving is indicated. The area in question is washed with 1 per cent cetavlon. The object of this is to try to prevent satellite furunculosis—a common local complication.

Fig 166.—I jecting procaine benzyl penicillin solution t the periphery of the inflammatory zone

Antibiotic Therapy —After antibiotics, notably penicillin, became available treat ment with these substances without surgical drainage was practised widely This cured some carbuncles, especially small ones, but it did not obviate the necessity for providing drainage in the majority of instances. The following is the best conservative treatment that has yet been evolved :—

One million units of procaine benzyl penicillin in 10 ml. of normal saline solution is prepared After sterilising the skin around the carbuncle, as described above the peni cillin solution is injected *subcutaneously* into the area peripheral to the inflammatory zone through four to six punctures, 300,000 to 600,000 units being placed about the lesion (*Fig* 166). The patient is put to bed, and the remainder of the penicillin solution is injected intramuscularly using of course a fresh needle.

The lesion is measured daily If after 24 hours its size is stationary no further local injection is given that day If after 48 hours there is no definite improvement, a second series of injections is undertaken. Sometimes a third treatment is required. Usually there is relief of pain within 12 hours. Parenteral penicillin is continued for at least seven days. As soon as the skin has broken (and in about one-half of the cases this has occurred before the patient is referred for treatment) the sensitivity of the infected organisms to antibiotics should be confirmed by laboratory tests. The causative organism is usually *Staphylococcus aureus* Should the organisms be insensitive to penicillin or the patient give a history of penicillin sensitivity penicillin treatment is abandoned in favour of achromycin 250 mg 4-hourly or another antibiotic, according to the laboratory sensitivity tests. Sinuses that develop must be kept open by the introduction of a sterile probe daily in order that pus and necrotic material can escape.

From the time of admission the carbuncle is dressed as follows —

Magnesium Sulphate Dressings.—A saturated solution of magnesium sulphate is prepared. Pieces of Gamgee tissue are cut of such a size that they overlap the extreme limits of the carbuncle. Two pieces of jaconet, which will more than cover the Gamgee are also provided. The Gamgee is wrung out in the magnesium sulphate solution so as to leave the former thoroughly moist, but not dripping wet.

The jaconet and a suitable overall bandage complete the dressing A piece of jaconet is used as a spare so that it can be washed in antiseptic solution and is in readiness for the next dressing The dressing is changed every six hours, but the patient is not awakened for this purpose

In the majority of cases a slough forms in the centre of the carbuncle and in due course this can be lifted off with dissecting forceps painlessly and without an anæsthetic. If the slough is slow to separate proteolytic débridement (*see* p. 140) can be used with advantage The clean underlying ulcer is covered with tulle gras dressings. Healing is usually rapid and complete. If the raw area is large, as soon as clean red, and flat granulation tissue is present healing can be expedited by skin-grafting

Operative Treatment.—While the relative inactivity just described is surprisingly successful in the majority of cases, provided there is not a contra indication to a general

anæsthetic there should not be undue reluctance to resort to the operative measures to be detailed immediately if (a) After 48 hours the pain is sufficient to cause the patient to request that something be done to relieve him or the nurse reports that he is not sleeping on account of pain (b) When the diameter of the carbuncle is 2½ in. (6·25 cm) or more (c) When profound toxæmia shows little signs of abating after 48 hours of general treatment including antibiotic therapy

It is emphasized that operative treatment should not be undertaken unless the carbuncle has been present for several days, and there is evidence of softening in its centre

The operative procedure consists of four phases. The important detail is that good access to the part is essential, as so often a carbuncle is situated on the nape of the neck, the back, or the buttocks. A few moments spent in consultation with the anæsthetist as to the patient's position during the operation is time well spent.

1 Further injections of penicillin around the carbuncle as detailed already

2. *Cruciate incision* A large cruciate incision is made into the whole of the carbuncle well into the red skin at the periphery On no account is any scraping performed loose slough can be removed by wiping it firmly with a gauze swab

3. *Excision of carbunculous skin* The four flaps resulting from the incision are dissected up and their apices are removed erring on the side of liberality

4 *Application of a closed dressing* The wound is packed with petroleum jelly gauze A viscopaste bandage or strips of flexible adhesive plaster complete the dressing which is not disturbed for a week unless there is some indication.

Carbuncle of the Face.—(*See* p. 819)

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Revised with the help of NORMAN M MATHESON M.R.C P (Lond.), F R.C.S. (Eng), F.A.C.S
Surgeon Ashford Hospital Middlesex

CHAPTER XII

ACUTE SPECIFIC INFECTIONS

ERYSIPELAS

EXAMPLES of erysipelas developing after surgical operations are now extremely rare most cases develop spontaneously or after some minor abrasion. It has been proved that bacteria other than specific streptococci can cause erysipelas. Fortunately the offending organisms are practically always Gram-positive cocci and thus particularly susceptible to modern chemotherapeutic measures.

General Treatment.—Systemic penicillin is used most often when contra indicated, as in the case of allergic reactions or penicillin-resistant organisms, chlortetracycline (aureomycin) achromycin and the sulphonamides constitute excellent substitutes.

Local Treatment.—So spectacular are the results of selective chemotherapy that local treatment is now of subsidiary importance If, however pain and local irritation become prominent features the inflamed area is washed gently with ether soap and 50 per cent ichthyol in lanolin is applied in the form of a paint, after which a thin layer of gauze is applied. In the case of a child 25 per cent of ichthyol is sufficient.

After the rash has died down subcutaneous abscesses may form. I have been called to treat many such cases and in some of these extensive collections of thin pus were found.

ERYSIPELOID

(*Fish-handlers Disease*)

This self limiting infection of the skin and subcutaneous tissues has long been recognized amongst workers dealing with fish and meat. It should always be borne in mind when an infected finger or hand is seen in a patient whose occupation exposes him to such industrial hazards. More recently erysipeloid has been found to be by no means unusual amongst men engaged in whaling and sealing in Antarctic waters (Hillenbrand).

Fig 167 —Erysipeloid.

Three or four days after a cut or scratch, the affected part becomes dusky or purplish in colour (*Fig* 167). The condition somewhat resembles the commoner pyogenic cellulitis, but is neither so painful nor so tender unless a mixed infection supervenes, suppuration is not a feature and con stitutional symptoms are generally slight.

Since spontaneous remission is the rule incisions should be rigorously avoided. Spontaneous *resolution, however usually takes two or three* weeks and to hasten this period of incapacity antibiotics become indicated. Penicillin (500,000 units 6-hourly) and aureomycin or chloramphenicol (in doses of 250 mg 6-hourly) have all proved *useful and time-saving remedies, often curing the* disease in a matter of days. Ichthyol in glycerin (15 per cent) is still the best local application.

CAT SCRATCH DISEASE

Of course any pyogenic infection can follow an abrasion but recently a special clinical entity has been recognised—*cat scratch disease* Although the aetiological agent has not yet been identified this particular disease can be distinguished from the more common infections by a specific intra dermal test

The local lesion, occurring about ten days after inoculation, sometimes presents as an infected abrasion. At times, however it is quite insignificant only to be followed by considerable and

perhaps suppurative lymphadenitis—with little or no intervening lymphangitis. Pus from the enlarged lymph-nodes is usually bacteriologically sterile a fact which might lead to the erroneous diagnosis of tuberculosis. General manifestations, such as hyperpyrexia, headaches, and rigors are sometimes dominant features. The axillary and inguinal lymph-nodes are most commonly affected but cat-scratch disease must also be considered in unexplained orbital cellulitis. Chloramphenicol (250 mg 6-hourly) or aureomycin, in the same dosage are recommended for treatment

ANTHRAX

It is estimated that over 98 per cent of cases of human anthrax in the United States are of the cutaneous type and the same is probably true in Britain. Although any part of the body surface can be affected, the face the back of the neck (from carrying hides) and arms are the favourite sites (*Fig* 168). As is well known anthrax is usually acquired

Fig 168.—Cutaneous anthrax. (*Dr A E Hodgson s case*)

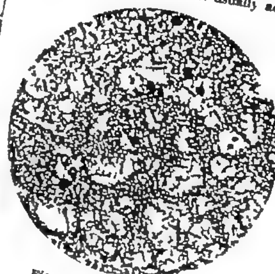

Fig. 169 —The anthrax bacillus in smear from a cutaneous infection.

from contact with hides, wool or hair Not so well appreciated, however is the fact that bones and horn can also be culpable. Crushed bones (bone meal) are used (*a*) in fertilizers, (*b*) in animal fodder and (*c*) in the manufacture of glue and gelatin. Crushed bones are imported largely from the East, where anthrax is extremely common, and from this source alone many cases in human beings and animals have occurred. So it comes about that anthrax should be seriously considered in the differential diagnosis of any atypical furuncle appearing in a person whose occupation exposes him to those industrial hazards.

The Incubation Period.—This is from three or four hours to three or four days. The first sign is the formation of a papule often surprisingly painless. Within twenty four to thirty-six hours small vesicles form on or about the now enlarged papule and the surrounding skin becomes red, œdematous and intensely irritating Lymphangitis extends to the regional lymph-nodes. About this time there is usually headache nausea, malaise and some fever the temperature registering 100 –101 F (37 8–38 3° C.).

In a case of suspected anthrax the vesicle should be pricked and a little of the serum examined by making a film and staining it by Gram s method. If the large anthrax bacillus is seen (*Fig* 169), the diagnosis is absolute Sometimes the bacillus is not found and animal inoculations have to be made to prove its presence If the angry pustule or the œdema make the diagnosis tolerably certain, the case should be treated as anthrax.

Treatment.—

a General —Penicillin is the main line of attack ; it is given systemically in doses of 500 000 units 6-hourly The pain soon subsides and smears from the lesion are usually negative in three days. The tetracyclines (aureomycin and terramycin) or chloramphenicol form efficient substitutes, and are given in doses of 500 mg 6-hourly at first

b Local —In the case of a limb, see that the part is elevated and effectively immobilized preferably by means of a plaster-of Paris slab

TETANUS

PREVENTION

Strictly observing the precautions concerning the administration of any serum (p. 79), inject 1500 international units (1 ml.) of antitoxin intramuscularly; repeat the injection at weekly intervals if the state of the wound suggests that the development of tetanus seems likely. When a patient has already been actively immunized tetanus toxoid should be given as a booster dose.

MANAGEMENT OF THE ESTABLISHED CASE

Immediately it is known that a patient suffering from tetanus is to be admitted, arrange for him to be received into a darkened, well-ventilated, side-room. Absolute quiet is essential, for the slightest noise may provoke a painful spasm. As thoroughly skilful nursing is of the utmost importance, see that a special nurse is in constant attendance both by day and by night. Oxygen therapy should be available at all times, and arrange for the tracheotomy set to be at hand, sterilized and ready for use.

Because the management of a mild case of tetanus will differ considerably from that of a severe one, it is essential to try to form some idea of the gravity of the illness early in its clinical course. Violent convulsions naturally indicate a grave infection. An incubation period of less than seven days suggests a bad prognosis; the same also applies when the interval between the first symptoms and the onset of spasms is less than forty-eight hours.

As soon as possible, interview the relatives personally. Not infrequently they can supply details of the history perhaps unable to be given or inadequately appreciated by the ill patient. Also, right from the beginning, explain to responsible relatives that a prolonged period of anæsthesia will probably be induced and that transfer of the patient to a special centre at another hospital might be required; permission for such eventualities should be obtained forthwith.

It is wise to call an early consultation between surgeon, physician, and anæsthetist, the services of all of whom will surely be called upon in any but the mildest case. Finally see that the routine medical care is supervised by a "tetanus team" covering each twenty-four hours.

a. **Allay Apprehension.**—This immediate requirement of the first order is obtained by *preliminary* sedation, as distinct from definitive sedation; the latter cannot be properly determined until the full demands of the case have been carefully assessed. As a rule pethidine (100 mg.) suffices in the first instance.

b. **Physical Examination** is deferred until the drug (initially prescribed) has had time to exert its effects. The clinical investigation should be carried out with the very minimum of disturbance. Besides recording all neurological features, particular attention should be paid to the respiratory system and its airway. The state of the bladder must never be forgotten. The temperature is taken in the axilla or groin, but if spasms are occurring frequently even this disturbance is avoided. Initial dressings of the wound must be done quickly, quietly, and deftly.

c. **Electrolytes.**—Few special investigations are essential in tetanus. Profuse sweating during convulsions is sometimes distressing. Gastric aspiration is frequently called for and so is the administration of parenteral fluids. For these reasons it is a good plan to have a biochemical standard by which to work in maintaining the fluid and electrolyte balance. Therefore, while commencing the next therapeutic step (the intravenous injection of serum), set aside a specimen of blood for estimations of the electrolytes and the alkali reserve.

d. ***Administer Antitoxin.***—After *preliminary testing to determine whether the patient* is sensitive to serum (p. 79), 200,000 international units of antitoxin are given intravenously as soon as possible after the diagnosis of tetanus has been made. This is the one and only dose for a week. On the seventh day the advisability of injecting a further 50,000 units by the same route is considered, but should there be definite signs of recovery the second dose is withheld.

e. **Antibiotics.**—Although there exists no proof that penicillin and any of the other antibiotics have a direct action on *clostridium tetani*, there is ample evidence of their beneficial effects in overcoming secondary invasion of the wound by the common pyogenic organisms. Moreover, pulmonary infections are now widely recognized as some of the

features of convulsive tetanus. Careful supervision of the patient, always important, assumes even greater importance when muscle relaxants are employed. Since tetanus itself carries a grave risk of respiratory failure, additional drug-depression of the muscles of respiration must be guarded against assiduously. The artificial control of respiration by up-to-date methods becomes an integral part of relaxant therapy. Some surgeons go further: drawing analogies between the patient under the influence of curare and the one with bulbar poliomyelitis, they prescribe procedures similar to the Danish techniques of treating bulbar poliomyelitis. Essentially these procedures consist of parenteral feeding under precise electrolytic adjustment, early tracheostomy and intermittent positive-pressure respiration-methods which can only be properly supervised by team work in a well-organized unit.

j Retention of Urine is not an infrequent accompaniment of tetanus, when treated by heavy sedation. It is conveniently dealt with by inserting a catheter of the Foley type.

GAS GANGRENE

Every instrument used in a case of gas gangrene should afterwards be autoclaved. The spores can resist 2½ hours' immersion in boiling water.

In civil life gas gangrene is comparatively rare. It is usually a complication of a compound fracture. In 30 per cent of cases of gas gangrene occurring at the Edinburgh Royal Infirmary the complication followed a strangulated enterocele in a hernial sac (A. White). Some of the most tragic cases of gas gangrene have resulted from a hypodermic injection with an infected needle and criminal abortions. Gas gangrene occurs occasionally as a superadded infection to gangrene from other causes, particularly in diabetic subjects. It is therefore advisable to give prophylactic treatment against gas gangrene in *all cases* of gangrene.

Prevention.—It has been abundantly proved that correct early excision of wounds has been of the greatest importance in the *prevention* of clostridial infections. Avoid tight bandaging and dispense with tourniquets unless absolutely essential. Prescribe penicillin (500,000 units every six hours) or achromycin (250 mg. four times a day) for every patient suffering from a contaminated wound. If a prophylactic dose[1] of anti-gas-gangrene serum (the contents of one ampoule[2] intramuscularly) were administered at the time of the treatment of the wound, doubtless the incidence of gas gangrene would be reduced still further.

Early Diagnosis. Suspect every wound where there is damage to muscle masses or main arterial trunks.

Pain is frequently the first indication of something amiss. An anxious look, slight dyspnoea, and a rising pulse (out of proportion to the temperature) increase the suspicion and urge an inspection of the wound. Obtain a swab from the exudate and from the aspirated contents of any blisters which might be seen near the injured part. The finding of large Gram-positive bacilli in these fluids is important, provided that it is *associated with clinical evidence of gas gangrene*; otherwise they might be contaminants. If streptococci are numerous, consider the alternative diagnosis of *haemolytic streptococcal myositis*.

Gas in the tissues gives an excellent shadow (*Fig.* 170). It must, however, be stressed emphatically that little diagnostic reliance can be placed on the presence of gas alone, but radiological evidence of gas in the tissues is of signal value in demonstrating the extent of a gas-forming infection. Gas certainly occurs in true gas gangrene (clostridial myonecrosis), but also in the less noxious *anaerobic cellulitis* (see p. 110) as well as with some commoner coliform and streptococcal infections. The detection of gas, whether by palpation or by radiography, must always be interpreted in the light of local appearances of the wound and general clinical signs. Often the wound emanates a peculiarly sickly sweetish odour.

Examination of the wound shows a surrounding area of red brawny swelling. The gas is sometimes above or below the wound, and may even be some distance away. The most

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[1] Clinical and experimental evidence indicates that anti-gas-gangrene serum is of no prophylactic value, but merely delays the onset of symptoms for 24 to 48 hours (Campbell).

[2] *Wellcome' brand mixed gas-gangrene antitoxin.* Each ampoule contains *Cl. perfringens* antitoxin 10,000 units, *Cl. septicum* antitoxin 5000 units, *Cl. oedematiens* antitoxin 10,000 units. It is unwise to give less than the whole content of the ampoule together with the usual dose of tetanus antitoxin. Where there has been undue delay the prophylactic dose should be large (two, or even three, ampoules).

frequent sites for this infection are the adductor region of the lower limb and the buttocks. In the upper limb the subscapular region is the most common. It is not unknown for gas gangrene to commence in a part of the body that has not been wounded; this occurs through embolic spread.

If energetic treatment is commenced early the prognosis of gas gangrene is not unduly grave, at least it does not warrant the gloom which surrounded the condition a few years ago.

Treatment.—Urgent operation takes pride of place in the therapeutic programme and first amongst the operative procedures is the extirpation of involved muscle masses.

Technique.—In many instances primary excision of the wound will have been performed previously; this does not deflect one from advising and carrying out wide exploration of the area at the earliest possible moment under penicillin or aureomycin protection. A large incision parallel to the long axis of the limb is made. The deep fascia is divided transversely the better to relieve tension and reveal a breadth of muscle. Foreign bodies, not forgetting pieces of clothing, are removed. It is *muscle* on which our attention is riveted. Is the muscle of normal colour (Fig. 171)? Does it contract on being pinched? Does it bleed on being cut? These are

Fig. 170.—Compound fracture of the femur, showing gas in the tissues, due to gas gangrene. (*James F. Brailsford.*)

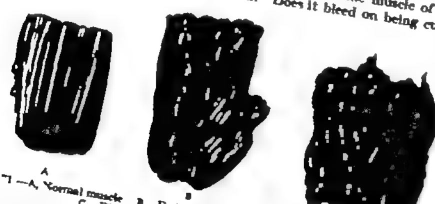

Fig. 171.—A, Normal muscle. B, Red death —note the cavitation by bubbles of gas. C, Black death. (*After Sir Cuthbert Wallace.*)

the criteria—unless the muscle passes all these tests, excise it until only surfaces which bleed freely are encountered. Local findings determine the extent of the operation. If necessary excise the whole muscular belly[1] or even a muscle group. Should the responsible tissue not be taken away, the chances of survival are remote—despite all the subsidiary aids now at the surgeon's disposal. After all diseased muscle has been removed and fascial planes have been opened up so as to permit their free drainage into the main cavity, injections of hydrogen peroxide into the subcutis and remaining muscles is an excellent practice. Of course care

[1] When a muscle, or group of muscles, has to be excised a careful operation note should be made as to *which* muscle or muscles. This will prove valuable if a reconstructive operation is contemplated later.

is exercised to avoid injecting the peroxide into a vein. Finally the wound is packed lightly with petroleum jelly gauze. The limb is suitably immobilized without tension, meticulous care being exercised if plaster casts are applied

Amputation.—Although current opinion is veering somewhat towards less radical procedures, in some cases of fulminating gas gangrene amputation above the infected area is the safest course After sectioning the bone, the muscles are inspected carefully If one muscle, or group of muscles, is affected, it must be excised up to healthy bleeding muscular tissue. If necessary the stump must be split widely On no account should the wound be sutured. Particularly in the thigh the short equilateral flap operation (*see* Chapter LXXXIV) is recommended.

Blood Transfusion.—Peripheral circulatory failure is always dreaded by surgeons. It is a characteristic accompaniment of gas gangrene, and so is anaemia because the hæmolysins of clostridia destroy red blood cells. Therefore set up a blood transfusion without delay

Antibiotics.—In the majority of cases, penicillin still remains the antibiotic of choice it is administered in massive doses, viz. a million units every three hours. Chloramphenicol forms a valuable alternative commencing with 500 mg every six hours, but this amount should be reduced as soon as possible Aureomycin is also useful given in the same dosage *and combined with the vitamin-B complex.*

Antitoxin.—At the present time, anti-gas-gangrene serum is taking a less prominent part in treatment. Polyvalent antitoxin (initial dose 30 000 international units) is best given by the intravenous drip method, gravitated very slowly and with adequate precautions to avoid anaphylactic complications. When the causative organism has been identified, appropriate monovalent serum can be employed. There are many proprietary preparations of antitoxin, and the doses vary but can easily be ascertained by referring to the literature which commendably accompanies every ampoule

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Revised by NORMAN M MATHESON M.R.C.P (Lond.), F.R.C.S. (Eng.) F.A C.S.,
Surgeon Ashford Hospital Middlesex

CHAPTER XIII

THE TREATMENT OF WOUNDS

The golden period for treating any wound is under six hours (J J Moorhead.)

Terminology.—To avoid confusion, it must be explained that the meaning of the word débridement which was adopted during the first World War has undergone a metamorphosis. It has now come to be used as an alternative term for primary excision of a wound. Wooley's present-day definition of débridement is removal of all foreign matter and aseptic excision of contaminated and devitalized tissue. The original meaning of débridement was opening up a wound to provide free drainage and counter-drainage when necessary as is done in cases that arrive too late for primary excision this strictly limited procedure is now known as wound toilet

Secondary excision of a wound is performed only in cases of gas gangrene

Primary closure[1] is closure of the skin at the time of the first surgical intervention. Delayed primary closure is closure during the first week. Secondary closure is closure after the first week.

First aid Treatment.—Except in cases of torrential arterial hæmorrhage when it should be applied as near to the wound as practicable the use of a tourniquet is to be discouraged, for the following reasons —

1 Not infrequently the tourniquet is applied in such a way as merely to impede the venous return, and blood loss is increased thereby

2. If properly applied, there is the danger of irremediable ischæmia of nerves.

3. In cases of considerable muscle damage when the tourniquet is released the patient passes into a state of profound shock from the sudden entry into the circulation of a massive dose of toxic substances derived from the pulped muscles.

The random use of hæmostats to control even arterial hæmorrhage is to be deprecated delving into the depths of a wound filled with blood is liable to result in the application of forceps to important undamaged structures, e.g., nerves. In addition, haphazard application of hæmostats to a bleeding artery often so damages it that reconstruction of the artery is rendered impossible (C. G Rob).

Usually the best interests of the patient are served by covering the wound with a clean handkerchief (sterile gauze is, of course preferable) held in place by a bandage very firmly applied. Nearly always hæmorrhage from an extremity can be controlled in this way Always advise against removal of a penetrating foreign body (e.g., a stick or a dagger) at this time possibly it has pierced a large blood vessel, and is temporarily plugging it

WHEN AND WHEN NOT TO PERFORM EXCISION OF A WOUND

Time.—The earlier the operation is undertaken, the greater is the prospect of success in this connexion it is not an exaggeration to say that minutes count.

Under 6 Hours.—If a wound can be excised within 6 hours of infliction (the golden period) in civil practice it is frequently justifiable to undertake primary closure (see p. 879) on the other hand, one of the cardinal rules of war surgery is no primary closure of wounds, except those of the face The reasons for this order are (a) war wounds are usually exceedingly contaminated (b) the patient is unlikely to remain under the charge of the surgeon who performed the original operation.

Between 6 and 12 Hours after Injury excision of the wound *without closure* should be the standard procedure Possibly if the patient has received early antibiotic treatment this safe period can be extended by 6 hours but the risk of spreading infection by excising a wound already infected is not entirely eliminated by antibiotic therapy

After an Empirical Interval of 1 Hours it must be presumed that the contaminated wound has become infected It is therefore imperative to limit operative procedure to

[1] The Committee on Wounds of the Medical Research Council recommended the use of the term closure instead of suture

Throughout the operation intermittent irrigation of the wound is carried out with warm isotonic saline solution. After excision has been completed small pieces of contaminated tissue can be submitted for bacteriological examination.

The Wound should not be closed unless each and all of the following stipulations have been complied with:—

1. The operation is undertaken within the "golden period" (6 hours).
2. The wound is not severely contaminated.
3. Excision has been performed to the satisfaction of the operator.
4. The patient is not suffering from shock at the time of the operation.
5. That there will be no pockets when the skin is closed.
6. The skin edges can be brought together without tension.

Even if all these requirements are fulfilled, wounds with major muscle damage are best left open.

It must be made abundantly clear that the above contra-indications to primary closure refer to wounds of the extremities and superficial wounds of the trunk. In wounds of other regions closure suture is not only advisable but in many instances is obligatory. These embrace wounds of the scalp, craniocerebral wounds (in which the dura is united, if possible, and the scalp is closed to prevent infection and herniation of the brain), wounds of the face (the excellent blood-supply enhances healing by first intention), wounds of the thorax (to prevent or correct the sucking type of injury), wounds of the abdomen (in which the abdominal wall is closed but the skin is approximated but loosely) and wounds of joints (in which the capsule, but not the skin, is closed). Each of these is considered in detail in the appropriate chapter.

Special Consideration when an Avulsed Flap of Skin is Present.—When the flap is unduly pale or bruised there must be no regret in excising and discarding it. If a partially avulsed area of skin and subcutaneous tissue has a broad base, and pressure on the base causes the flap to pale, and the colour returns when the pressure is released, there is a temptation to cleanse the flap and suture it into position. More often than not, because its venous return is inadequate, abetted by infection of attached fat, within a few days the flap becomes œdematous. The resulting swelling seriously reduces the arterial supply, and gangrene of a varying portion of the flap occurs. The proper course to adopt is as follows: the wound beneath the flap must be excised in the usual manner. If the flap appears healthy and possesses a broad base, the fat from its under surface is excised, the skin edges are trimmed as necessary, and the flap is sutured loosely into position to prevent it contracting and curling up.

When primary closure of the wound is considered inadvisable, a better plan is to excise the flap, remove all the attached subcutaneous fat, wrap the piece of skin in gauze wrung out in saline solution, and place the packet in a refrigerator. If all goes well, the skin can be used as a full thickness graft at the time of delayed primary closure of the wound.

Dressings when the Wound is left Open.—If it is hoped that the wound will be suitable for delayed primary closure (see p. 137) petroleum-jelly gauze should not be used for the purpose of packing the wound. Its greasy nature does not allow absorption of moisture into the dressing, as shown by the fact that when this dressing is removed the skin is pale, rather swollen, and does not hold stitches well. The best dressing is fine-mesh dry gauze, which does not adhere to granulation tissue unduly, and can be removed easily under general anæsthesia. The wound should not be packed tightly; rather a few layers of dry gauze are laid in the wound between the raw edges of the tissue, particularly separating any deep crevices. The mouth of the wound is then covered with gauze, and compression is applied by strips of adhesive plaster. In the case of a limb, a plaster cast is preferable.

Immobilization.—Healing is more rapid, the patient is more comfortable, and the spread of infection by muscular movement is lessened if the part is encased in plaster-of-Paris, which must be split throughout its length before the patient is removed from the operating table. To bivalve an encircling cast ensures that there will be no interference with the blood-supply when swelling of the wounded part, which is almost inevitable, occurs. Neglect of this precaution has often led to disastrous sequelæ (gangrene, Volkmann's ischæmia). When practicable, the part should be elevated during the early post-operative period; this discourages œdema and thrombosis, and favours optimum healing.

Sera and Antibiotics: Prophylaxis against Tetanus.—In recent years the almost complete absence of tetanus complicating war wounds in soldiers is largely due to the fact

that soldiers are actively immunized by injection of tetanus toxoid. Toxoid does not contain horse-serum. The titre of antibodies remains high for years, and if the patient is wounded at any time during life a booster dose of 0·5–1 ml of toxoid will protect him from tetanus.

Tetanus antitoxin provides a real protection for those who have not been immunized but it should not be given until a preliminary test for sensitization has been performed. If it is given to a susceptible patient without desensitization (see p 79) death may follow instantly. The dose should be 100 units per year of age up to 15 years or 1500 units for an adult if seen within the first 24 hours of wounding After 24 hours the dose should be increased to 3000 units, and doubled after each day up to a total of 12 000 units.

Anti-gas-gangrene serum is probably valueless as a prophylactic measure, see p. 130 Provided devitalized tissue has been excised, the antibiotic therapy about to be recommended is likely to afford protection against clostridia as well as other organisms.

Antibiotic Therapy is adjuvant to but in no way a substitute for meticulous débridement in the case of early wounds, and adequate drainage in late infected wounds. Considerable help in prophylaxis against infection of contaminated wounds is gained by the administration as early as possible of penicillin and in the case of abdominal perineal or any wound grossly contaminated, by the administration of streptomycin also The usual dose is 500,000 units of penicillin and 0 5 G of streptomycin intramuscularly repeated 12 hourly for 5 days. As Pulaski emphasizes, in a severely shocked person it is of little avail to administer antibiotics intramuscularly for as in the case of morphine absorption is delayed and irregular In such circumstances the only reliable method of ensuring an adequate blood level is to administer the antibiotic intravenously with the intravenous fluid for shock. A suitable and safe antibiotic for intravenous use is terramycin in doses of 500–1000 mg 12 hourly As soon as the shock is overcome, the injections are given by the intramuscular route

Fluid Replacement.—Fluid replacement must be commensurate with the needs of the patient. Regarding blood loss following injury Grant and Reeve found the volume of damaged tissue to be a valuable index of the blood loss the patient s hand—fist closed for deep wounds and open hand for surface wounds—was used as the unit of volume

Size of Wound	*Tissue Damage*	*Blood loss*
1 Small	Less than one hand	Usually less than 10 per cent; rarely more than 20 per cent
2 Moderate	1–3 hands	20–40 per cent
3. Large	3–5 hands	About 40 per cent
4. Very large	5 or more hands	50 per cent or more

In all patients the pre-operative loss, if more than 2 pints (1 2 l.), and the post-operative loss, determined fairly accurately by swab weighing should be replaced by blood transfusion.

Selecting Cases for Delayed Primary Closure—Experience has shown that the fourth or fifth post-operative day is the optimum time for delayed primary closure It is at this time that œdema of muscles is beginning to subside and the skin edges can be brought together with less tension. Consequently on the fourth or fifth post-operative day the patient is taken to the operating theatre, the dressings are removed and the wound is inspected for signs of infection. If infection has supervened, the first duty is to apply two or three swab-sticks to various parts of the wound, and send these for culture and sensitivity of the infecting organisms to antibiotics If the wound is purulent, or if there are signs of lymphangitis or cellulitis, in the absence of signs of gas gangrene the wound is packed lightly with petroleum jelly gauze which cannot be bettered in the early stages of wound infection.

In the great majority of these cases where efficient primary excision has been carried out, the patient s pulse and temperature will be normal, and the wound will be found to be in an eminently suitable state for delayed primary closure

DELAYED PRIMARY CLOSURE

The wound is packed with sterile gauze and the surrounding skin is shaved and meticulously cleansed with a detergent Gloves having been changed and fresh towels arranged around the wound, it is irrigated gently with saline solution to remove all blood and debris. Fresh towels are placed in position. It will be found that the skin edges have become adherent to the sides of the wound. The edge of the skin is picked up with tooth dissecting forceps and a closed hæmostat is insinuated into the subcutaneous tissue and the skin is freed by blunt dissection for at least 2 in. (5 cm.) from the skin margin all around

the wound. This somewhat crude procedure, in which a certain amount of force must be used, is chosen because it has the inestimable advantage over sharp dissection in that bleeding is very slight. The objective is to be enabled to bring the skin edges together without tension. If by trial this has not been attained, undermining to an extent of 4½–5½ in. (12–14 cm.) beneath each flap is usually safe. Tension can often be reduced by judiciously extending the wound by a small incision at either end of the original wound.

To avoid closing skin under tension, at the Birmingham Accident Hospital the following expedient is used. Very fine suture material, e.g., 0000 silk, is employed, and suturing is commenced from each end. If there is sufficient tension to cause the suture to snap when it is being tied no further sutures are inserted.

Partial Closure and Skin graft is an excellent method in wounds that present a tension problem in part of the involved area, whereas the remainder can be closed without tension by free mobilization of flaps.

Relaxing Incisions are employed only when none of the above expedients is sufficient to bring together the skin edges without tension. A good rule is that the length of the flap should not be more than twice its width. Long wounds, therefore, require relaxing

Fig. 173.—Showing the rationale of relaxing incisions.

incisions at a considerable distance from the wound edge in order to allow for sufficient width. At the end of the operation the defect left by relaxing incisions (*Fig.* 173) should be covered by split thickness skin-grafts.

Closure of Adjacent Wounds requires careful planning to avoid tension. The flap intervening between the two wounds can usually be undermined and mobilized in one direction only to cover one of the wounds; the other should be skin-grafted. In other instances the intervening flap may be long and narrow, so that undermining it is liable to place the viability of the flap in jeopardy. In such circumstances it is better judgment to graft both wounds.

General Technique of Delayed Primary Closure.—Granulation tissue is wiped gently off the surface of the wound with a swab. Complete hæmostasis is of vital importance. It should be achieved as far as possible without the use of ligatures. No buried sutures are employed.[1] If there are known pockets a small tube must be inserted through a stab incision. It is unnecessary to freshen the skin edges, a procedure that sacrifices some much-needed skin. Heavy suture material is not required; the skin edges are brought together with alternating everting and plain sutures of fine, strong material, e.g., 000 black silk. A pressure dressing is applied by means of gauze over wool, retained by a crêpe bandage, or a divided plaster cast is applied. Every effort must be made to minimize and decrease local œdema. To this end elevation of a limb for 24–48 hours is desirable.

The benefits conferred by delayed primary closure are threefold:—Firstly, it provides a natural covering for the tissues, thus preventing continued ... serum from the wound; this, in itself, often brings about remarkable improvement i... ... general condition. Secondly, from the time the skin h... the danger of ... without is reduced to zero. Thirdly, healing of the... expedited by ... and scar tissue is reduced proportionately; there ... more acc... primary closure.

Post-operative Care.—A ... the pulse ... an ... where infection supervenes there ... ay in rele...

If all goes well, the sutures ... the

[1] Colonel D. Fl... an ... in the ... the finest cotton w... d it ... te der... healed *per primam*

little with wound healing. The Carrel-Dakin technique is also very satisfactory for sterilizing the surface of a wound prior to secondary closure or skin-grafting.

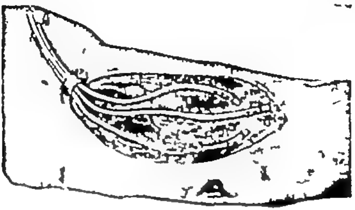

Fig. 175.—The arrangement of tubes for Carrel-Dakin's irrigation. Note that a distributor is not employed. (*After Seymour Barling.*)

Edmonds's Sandwich Dressing is excellent for flat wounds. One, two, or more irrigation tubes are sandwiched in six or more layers of gauze, as shown in *Fig.* 176. The flat wound is covered by a single piece of tulle gras. The sandwich is laid upon it, and after covering it with ample dressings, it is bandaged in position. It is often convenient to connect the irrigation tube to a saline drip apparatus filled with the chosen solution. The sandwich dressing is most effective when it is desired to clean up a flat wound prior to skin-grafting.

Fig. 176.—Edmonds's sandwich dressing.

Proteolytic Débridement of Sloughs.—

Streptokinase (SK.) and Streptodornase (SD)[1] are proteolytic ferments obtained from the filtrate of streptococci. Working in combination, these enzymes dissolve small sloughs and loosen larger ones without attacking living tissues. These substances are supplied in ampoules containing SK. to SD 4 : 1 in the form of a white powder, which is dissolved in 10 ml. of normal saline. Gentleness must be exercised in making the solution, as shaking and stirring destroy much of the enzymic contents. It is used as a wet dressing or, in the case of a sinus, is injected through a polythene tube. The enzymic material is applied in doses of 20,000 units of SK. and 5000 units of SD 6-hourly until the slough has been digested; the enzymes have no action on collagen fibres, consequently larger loosened sloughs remain bound to viable material, but can be picked off in small pieces without causing pain. Cooper et al. have found the best method of applying SK. and SD is by spray dissemination with an atomizer. This is followed by the application of a water-soluble jelly which also contains the enzymes. This, in turn, is covered with a dry dressing. The entire process is repeated four times a day, the evening dressing being left on all night. After cleansing in the morning, the wound is left exposed for two hours, the objective being to prevent maceration of the surrounding tissues by constant moisture. The sensation of burning can be prevented by incorporating 1 per cent procaine in the vehicle. The rapid development of granulation tissue during SK. and SD treatment presents a problem. Powdered sucrose (XXXX confectioner's sugar) applied to the area reduces the oedema of

[1] SK. and SD—Varidase. Lederle Laboratories division, Cyanamid Products Ltd., Bush House, Aldwych, London, W.C.2.

granulation tissue. This expedient has an obvious advantage over cauterization seeing that it produces no necrosis. The powdered sugar when required is substituted for the evening dressing of the enzymes.

While these enzymes are being used purulent exudate lessens in amount and becomes more serous. Alternatively —

Crystalline Trypsin[1] can be used. It is produced from beef pancreas, and is supplied in ampoules containing 200 mg. of active principle which is a white powder. With the enzyme a phosphate buffer is also supplied in 5 ml. ampoules. Before use the powder is dissolved in the buffer solution, which has a *p*H range from 3 to 8 that activates the enzyme. It is applied as a wet dressing or the powder is insufflated followed by spraying of the buffer solution.

It is sometimes necessary to stop the action of the enzyme immediately; this can be done by irrigating the wound with sodium bicarbonate solution, a heaped teaspoonful of sodium bicarbonate to half a pint (250 ml.) of saline solution. If a wet dressing is to be used, trypsin is applied every three hours for three days, by which time the maximum effect is obtained. The dose varies from 30 mg. for a circumscribed cutaneous ulcer to 0 mg. for an extensive necrotic wound. When proteolytic débridement with trypsin causes exposure of vascular healthy tissue local burning pain is experienced. The burning pain can be abolished by administering benadryl 50 mg. by mouth. In most cases the enzyme stimulates the production of healthy granulation tissue.

Reactions.—In a few patients untoward reactions occur usually within 15 minutes of the application of trypsin. The temperature rises, sometimes ushered in by a rigor; this is followed by profuse perspiration, and not infrequently diarrhoea. In such cases the proteolytic activity must be stopped by irrigating the wound with sodium bicarbonate solution, and from thenceforward treatment with trypsin must cease.

Less frequently a patient becomes sensitized to SK and SD which necessitates stopping this treatment.

Conclusions.—Trypsin is the proteolytic enzyme of choice for superficial wounds. SK and SD give better results than trypsin in the case of deep-seated and multilocular wounds.

SECONDARY CLOSURE

When the time interval is seven days or longer the tissues become indurated and the epidermis grows into the edges of the wound. It is therefore necessary to freshen the skin edges. In long-standing cases with an overgrowth of granulation tissue and the presence of a contracting scar it is often best to excise the wound formally. In other respects the principles governing delayed primary closure are applicable to secondary closure.

BITES

Human Bites.—Because the wound becomes contaminated with aerobic and anaerobic bacteria, fusiform bacilli, and spirochaetes, from the mouth, if the patient is not treated until infection has supervened, a human bite can prove very dangerous. Although not strictly a bite, a common type of injury of this kind is an incised wound over the knuckles resulting from a clenched fist of one combatant striking the front teeth of his opponent. The joint is usually penetrated, but the tract closes when the fingers are extended. If the patient presents before infection has supervened, the wound caused by a human bite should be excised under antibiotic cover. In the case of a wound over the knuckle if the joint capsule has been penetrated, a portion of the capsule must be included in the dissection and in this instance the capsule should be left unsutured.

Because of the heavy contamination the question of primary closure of a wound resulting from excision of a human bite never arises, except, possibly, in the case of the face. When the patient is seen only after infection has supervened, free drainage followed by moist (saline) gauze dressings is the treatment recommended. In all cases the administration of either a combination of penicillin and streptomycin, or aureomycin should be commenced as early as possible and continued for at least 5 days.

Dog Bites.—The treatment of dog bites by cauterization with fuming nitric acid or pure carbolic acid still lingers, the reason given being that such cauterization is some protection against hydrophobia. Bites thus treated take an inordinately long time to heal and the resulting scar is often hideous. The first-aid treatment should be washing with

[1] Trypsin—Tryptar. Armour & Co., Ltd., Hampton Park, Eastbourne.

soap and water or a detergent. In Great Britain there has been no case of hydrophobia since 1922, and consequently dog bites should be excised in the same way as any other wound. Provided the case is an early one there is no good reason to prohibit primary closure. Tetanus prophylaxis and the administration of penicillin are part of the routine treatment. In some other countries hydrophobia has not been exterminated. It should be known that the bite of a cat, wolf, jackal, or vampire bat, as well as that of a dog, can inoculate the victim with the virus. When there is a possibility that a bite is thus infected, the wound should not be closed after excision. The incubation period of hydrophobia varies from two weeks to several months, depending upon the length of the peripheral nerves to be traversed by the virus. Consequently, in bites on the face, head, or neck, the incubation period is likely to be short. It is a sad fact that in these cases, where the path from the wound to the brain is short, vaccine, even if commenced at once, seldom succeeds. Therefore in these cases the main hope lies in early thorough excision of the wound. Once hydrophobia has developed there is no possibility of curing it.

Prophylactic Pasteur therapy should be given :—

a. If the dog or other animal cannot be isolated and observed.

b. If the animal under observation demonstrates manifestation of rabies.

c. During the period of observation of the animal, if bites are multiple, or are on the face, head, or neck.

There should be good reasons for giving prophylactic specific treatment, because the vaccine is not entirely innocuous; sometimes there are neurotoxic sequelæ. When vaccine is considered advisable, 3 ml. is given subcutaneously daily for at least 14 days.

Snake-bites contain two principal types of toxin—neurotoxin and hæmotoxin. Neurotoxins predominate in the venoms of cobras and mambas, while hæmotoxins are present in the venoms of adders of the old world and the rattlesnakes of the new world. In addition to hæmotoxin, the venom of certain vipers, notably Russell's viper (which is found in India, Burma, Malaya, and the Dutch East Indies), contains thrombase, which, if injected into a small animal, causes rapid thrombosis. In man thrombosis from this cause is rare, but the thrombase causes local necrosis.

Neurotoxins can kill rapidly by causing paralysis of both the medullary centres and the peripheral nerves. By enzymic action hæmotoxinic venom damages the lipoid coat of erythrocytes, the capillary walls, and the tissues themselves. This results in hæmolysis, extravasation of blood, and the formation of histamine. The shock that follows is believed to be due to the liberation of histamine. After recovery from a severe hæmotoxic snake-bite, fibrosis of the hæmatomata that are wont to occur in the kidneys, heart, and liver sometimes lead to chronic invalidism. In Great Britain the venom of the adder is relatively weak, and although serious symptoms can develop, especially in children, the bite of this snake is seldom fatal.

Treatment.—

1. The immediate treatment of snake-bite of a limb is to apply a tourniquet above the bite. The tourniquet perforce is usually of the improvised type, using a stick to twist a handkerchief or bandage tied around the limb. The tourniquet is tightened until the pulse distal to the tourniquet is no longer perceptible. Then sufficient release of the twists is given to occlude the main veins, but not the arteries, and the limb is rendered blue (not white). In the case of a digit a piece of string or, better, an elastic band is used to produce the congestion. In regions where a tourniquet cannot be applied the prognosis is more grave, but absorption of the venom is hindered by pressing the rim of a glass or a cup over the area.

2. It is of the highest importance to make an incision into the area of the bite without delay. When possible this should be performed under thiopentone anæsthesia. The incision should pass through the fang marks, and in the case of a limb it is made in a longitudinal direction, so as to avoid cutting nerves. When the bite is of a deadly snake, the incision should be 3 in. (7.5 cm.) long, and in all cases it is carried down to the deep fascia. The object of the incision is to promote considerable bleeding from the affected part and thereby minimize absorption of the poison. To this end the venous tourniquet is required for as long as 18 hours. When possible, arrangements for blood transfusion should be made to replenish the blood-loss. During the whole period the wound should be irrigated from time to time with boiled water to diminish clotting. Many authorities recommend rubbing potassium permanganate crystals into the wound as soon as the incision has been made. It is stated that much of the unabsorbed poison is neutralized thereby.

3 An attempt is made to suck out the poison. If oral suction is used it should not be direct lest the venom enters a crack or an abrasion of the lip. A piece of rubber glove with a small hole in it laid upon the wound will obviate this danger. Suction should be continued for 5 minutes. Bottle suction is preferable; a partial vacuum can be created in a wide-mouthed bottle by burning paper therein.

4 Antivenene should be administered as soon as possible. Without antivenene bites of highly poisonous snakes often prove fatal. On the other hand antivenene alone does not save life. At least two ampoules of serum are required. Each ampoule contains 10 ml. of antivenene. Antivenene is given cold as this minimizes untoward reactions. 0 5 ml. of adrenaline hydrochloride 1–1000 should be in readiness for injection if anaphylactic phenomena occur. The same dose is given irrespective of the age and weight of the victim. Half to 1 ampoule is injected into the region of the bite; a further 1–1½ ampoules is injected intramuscularly into the thigh or if the patient's condition is grave, into a vein. In the absence of rapid improvement the dose is repeated at 4-hourly intervals. Sometimes the contents of 6–10 ampoules has to be used.

Most areas where poisonous snakes are endemic have their own polyvalent antivenene. In South Africa the Institute of Medical Research and the Fitzsimond's Institute are the main manufacturers. In Great Britain antivenene is imported from the Pasteur Institute, Paris, and is difficult to obtain urgently; usually application has to be made to the Ministry of Health. The serum is made by immunizing horses to increasing doses of adder and cobra venom, or whatever poisonous snakes abound in the particular vicinity.

5 The affected part should be immobilized. If the lower limb has been bitten the two limbs should be bound together. In the case of the upper limb it is splinted or bound to the trunk. Rest to the part is imperative to minimize distribution of the venom by muscular contractions.

6 The general treatment of shock, if present, does not differ from that of shock from other causes. In cases of cobra and mamba bites artificial respiration is sometimes required.

Spider Bites.—The *Latrodectus mactans* or the black widow spider is about 1 3 cm wide of body and the long slender legs span up to 5 cm. The body and legs are black and there is a bright red mark on the abdomen. Following a bite, sudden severe local pain develops with the rapid onset of œdema and redness. In 15 minutes there is a generalized burning sensation, with acute abdominal pain and cramp in the limbs; a burning pain in the soles of the feet also occurs. The abdomen becomes board-like, but not tender. The condition may progress to gangrene of the skin, jaundice, and death.

Intravenous calcium gluconate, 10 ml. of a 10 per cent solution, gives immediate relief. This may be repeated as required. Magnesium sulphate compresses are applied locally. (J. H. Marks.)

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CHAPTER XII

SOME POST OPERATIVE COMPLICATIONS

The more one sees of the practice of surgery the more one is impressed by the relative frequency of unforeseen complications and when one carefully thinks out the cause of these troubles it is only to find that most of them could be prevented (John H Watson)

PULMONARY COMPLICATIONS

Post-operative pulmonary complications are still very common. Men are much more frequently affected than women and in the case of abdominal operations, which carry the highest incidence, this can be explained by the relative ease with which women can breathe freely when the abdomen is strapped tightly men are much more reliant upon abdominal respiration. Chesty subjects are frequently encountered in emergency surgery and a great deal can be accomplished by precautionary measures.

PREVENTIVE MEASURES

1 In the chronic bronchitic the best prophylactic treatment is pre- and post-operative oral inhalations of 1 ml. of 1 per cent solution of isoprenaline (neo-epinine[1] No 1 spray) by means of a hand atomizer followed by 15 to 20 minutes of postural drainage. Isoprenaline is a powerful bronchodilator and vasoconstrictor

2. The surgeon should see for himself that the patient is adequately wrapped up on leaving the theatre

3. Prophylactic penicillin therapy is very valuable. The greatest single factor leading to a diminution of post-operative *pneumonia* has been antibiotic therapy When pulmonary complications are feared it should be commenced within a few hours of an emergency operation

4 Neither antibiotics nor post-operative breathing exercises have had any effect in reducing the prevalence of post-operative atelectasis. None the less, breathing exercises are valuable in preventing other complications. All that is necessary is that the patient should be supervised in taking six deep breaths every waking hour Unquestionably an ideal method is to relegate the supervision of the exercises to a physiotherapist.

5 Inhalations of CO_2 to promote deep breathing are dangerous. The effect is to drive viscid secretions deep into the bronchioles.

6 The administration of atropine post-operatively should be eschewed for to render bronchial secretions viscid is the very thing to be avoided

7 The evil of overloading the circulation with intravenous fluid, and the consequent hypostatic pulmonary congestion that results therefrom, has been emphasized in this book.

8 Inhalation of gastric contents occurring during operation or while the patient is coming round from the anaesthetic is not the extremely rare occurrence many believe. This complication, unless treated immediately and energetically (see p. 101) carries a high mortality It is the surgeon's responsibility to ensure that the stomach is empty before operation and that it is kept empty in the immediate post-operative period. Muscle relaxants, which render the oesophageal sphincter atonic have led to an increased incidence of this complication. These drugs should be used only with an inflatable cuffed endotracheal tube in place

9 The fundamental treatment of post-operative atelectasis is postural-percussion drainage (*see Figs* 179 180) and the surgeon should be prepared to demonstrate the necessary manœuvres himself on the least provocation.

ATELECTASIS (COLLAPSE OF THE LUNG)

Atelectasis is a supremely remediable forerunner of post-operative pneumonia. The condition often escapes notice pneumonia sets in. Without doubt atelectasis is a subject that merits close attention, and it is most desirable to be able to formulate a mental picture

TREATMENT

Postural-percussion Drainage.—If the operation was an abdominal one (and atelectasis is most common after upper abdominal operations) a tight abdominal binder is applied *temporarily*. The patient's posture is changed to that shown in *Fig.* 179. It should be noted that the foot of the bed is raised upon a chair and that the patient is lying with the involved lobe uppermost, which brings the mouth of the occluded bronchus into a dependent position; to exaggerate the position a pillow is placed beneath the lower part of the thorax. The surgeon stands behind the patient, placing one hand upon the uppermost shoulder; using this hand he rolls the patient slightly forwards on to his abdomen. The patient is instructed to place his uppermost hand over the abdominal incision, and this is reinforced by the surgeon's free hand. Coughing is encouraged until the air-passages appear to be free.

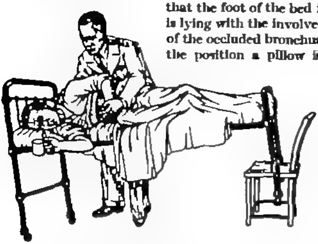

Fig. 179.—An effective method of clearing the bronchial tree in cases of collapse of a lung. The patient is lying on the sound side. (*After A. E. Moore.*)

The patient is then rolled on to his face. The left hand is placed over the collapsed lung and the back of the hand is struck smartly with the right fist (*Fig.* 180). This postural-percussion drainage, if carried out soon after collapse has occurred, frequently loosens the plug of mucus, which is coughed up, allowing re-expansion of the lung to occur.

Postural drainage *per se* should be repeated every four hours for as long as considered necessary. If the outpouring of sputum is copious the patient can remain in the lateral position for as long as half an hour at a time. Oxygen can be given, but CO_2 is contra-indicated, as the hyperventilation it produces may lead to aspiration of viscid secretion into the smaller bronchi. Isoprenaline inhalations before each session are valuable; alternatively, if the sputum is tenacious inhalations of tinct. benzoin. co. can be substituted

Fig. 180.—Postural-percussion drainage in massive collapse of the lung.

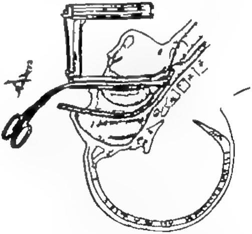

Fig. 181.—Endotracheal catheterization.

with advantage. To ensure effective inhalations, in the absence of suitable apparatus an ordinary paper bag can be used as a mask, and the spout of the steam kettle passed through its base.

The longer the lung is allowed to remain collapsed, the more difficult it is to relieve the condition by postural measures. When there is evidence of an accumulation of secretion in the tracheobronchial tree that cannot be evacuated by the simple methods described above, aspiration should be undertaken.

Endotracheal Catheterization; Bronchoscopy.—Usually a urethral catheter size 2 passed into the trachea, is effective. It is introduced preferably through the nose

through the mouth. Especially if the throat is sprayed cautiously with 5 per cent solution of cocaine the procedure can be carried out with but little discomfort. The catheter is guided into the trachea by means of a laryngoscope and suitable forceps, as shown in *Fig.* 181. If the catheter is connected to a sucker this frequently relieves lobar atelectasis, or even massive collapse.

When endotracheal catheterization fails bronchoscopy is the correct procedure. The services of an especially skilled bronchoscopist are essential for the operation must be carried out in the patient's bed. Through the bronchoscope the affected bronchus is aspirated and mucus, together with the plug, is sucked out.

PULMONARY COMPLICATIONS IN UNCONSCIOUS PATIENTS

Patients who develop pulmonary complications by reason of long period of stuporous states should be tracheotomized. It is advised that tracheotomy should be resorted to in all patients having excessive bronchial secretions that cannot be adequately evacuated by their own effort or by catheter. The secretions can then be aspirated easily at regular intervals through the tracheotomy opening.

POST-OPERATIVE PNEUMONIA

The treatment of post-operative pneumonia, once it has developed, differs not at all from other types. Whenever possible a medical colleague should be asked to superintend the treatment.

ACUTE PULMONARY ŒDEMA

Although he had received only 2½ pints (1¼ L.) of intravenous dextrose-saline solution in 24 hours, W. P., aged 44, who had had partial gastrectomy performed under local anaesthesia 30 hours previously presented typical signs of pulmonary œdema.

The patient was a fortitudinous, uncomplaining man who, in addition to his long history of chronic gastric ulcer, was troubled with chronic bronchitis. On a routine visit the patient was found to be dyspnœic but uncomplaining. His nail beds were blue and his pulse was almost imperceptible. The staff nurse reported that an hour previously the patient's pulse had been quite satisfactory, that he had had a good night, and that his condition had given rise to no anxiety. The patient's abdomen was examined and nothing amiss was found. The respirations were 43 per minute, the temperature was 100·4° F. (38° C.), the pulse 140 and feeble. A stethoscope applied to the chest revealed moist râles.

It was evident that the patient was suffering from either pulmonary œdema or massive collapse of a lung. Because of bilateral dullness over the bases of the lungs, pulmonary œdema seemed the more probable—a supposition that was confirmed by a physician a little later.

The continuous intravenous infusion was discontinued, and continuous oxygen and carbon dioxide given with nasal catheters. Digoxin, 0·5 mg., was injected intravenously. Coramine 2 ml. intramuscularly 4-hourly was ordered. The patient said he felt choked up with sputum, and as the pulse was a trifle better as a result of the cardiac stimulants the postural treatment depicted in *Fig.* 179 was undertaken with the satisfying result that the patient brought up a quantity of watery sputum. Four hours later the physician injected 2 ml. of mersalyl intramuscularly. This was followed one hour later by the passage of 12 oz. (350 ml.) of urine. Within three hours his condition had improved. The cyanosis had gone and his breathing was much quieter. A radiograph[1] of the thorax taken with a portable machine showed some irregular scattered opacities at the right base resembling patchy consolidation. The pulse rate was now 120 and the blood pressure 105/80 mm. Hg. The patient continued to improve and 24 hours later was pursuing a normal convalescence.

Summary of Treatment.—

1. Continuous intravenous fluid discontinued.
2. Intranasal oxygen and carbon dioxide.
3. Intravenous digoxin (0·5, 0·25 and 0·5 mg.).
4. Postural-percussion drainage as in *Fig.* 180.
5. Four-hourly nikethamide (coramine) (2 ml. intramuscularly).
6. Mersalyl (2 ml. intramuscularly).

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[1] The typical radiological findings of acute pulmonary œdema are dense cloudy opacities spreading from the hila, obscuring the hilar vessels and lung markings; the apices are spared. With treatment these signs rapidly disappear. (F. Jackson.)

New knowledge indicates that considerable quantities of fluid can be tolerated in the respiratory passages as long as no foam is formed. An anti foaming agent, octanol, administered by nebulization through a closed system using an oxygen mask with a humidifier interposed has been very successful in the treatment of pulmonary ædema.

PERSISTENT HICCUP

Persistent hiccup is a distressing complication, most often seen after upper abdominal operations, although it is by no means rare in uræmic subjects. It is a serious complication, distressing for the wretched patient, upsetting to the other patients, and distracting for the staff Morphine sometimes controls it for a time, but persistent hiccup is almost untouched by this drug Other drugs that have been advocated for the relief of this condition are legion. The latest is chlorpromazine (largactil), 20–50 mg. intravenously

Fig 182.—Type of mask used for CO inhalations. The ample air holes prevent a high concentration of CO_2.

Management.—It will be assumed that carminatives, sedatives, and holding the breath have been tried without avail. Commence by doing three things: (*a*) Pass a gastric aspiration tube to eliminate acute dilatation of the stomach (*b*) Ascertain the urinary output, and in relevant cases collect a specimen of blood for a blood urea estimation (*c*) Examine the thorax, with special reference to pleurisy After these preliminaries the following therapeutic programme should be inaugurated :—

CO_2 *Therapy*.—A homely method is to get the patient, nearly always an adult male, to breathe in and out of a thin paper-bag for half a minute at a stretch. *The inhalation of 5 per cent CO_2 is often effective.* It is quite useless to blow the CO_2 in front of the patient's nose it must be given properly with a dental gas inhaler or a similar mask (*Fig* 182) Inhalation should be given from 3 to 15 minutes and charted thus :—

Time	5 per cent Mixture Inhaled for	Freedom from Hiccup
8.30 a.m 4 a.m.	10 minutes 5	20 minutes 30

It should be remembered that plenty of air must be given 5 per cent CO_2 is the concentration indicated There is no reason why a skilled nurse should not give these inhalations if she is instructed properly but in some hospitals the matron will not allow them to do so. It was for this reason that I designed the Sparklet resuscitator with mask (*Fig* 183) With this simple apparatus even the intelligent patient can administer the CO_2 himself he cannot possibly do any harm with the amount of CO_2 contained in one charge

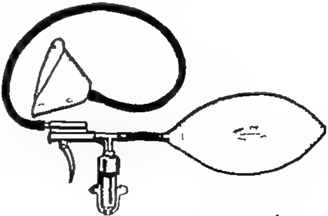

Fig 183.—Sparklet resuscitator with mask.

Efficient CO_2 therapy brings some relief to all patients with hiccup. In 50–60 per cent of cases the condition becomes definitely under control if not cured within 48 hours. Unless the hiccup chart registers a substantial improvement in 24, or at the most 36 hours, it is inadvisable to procrastinate in carrying out injection of the phrenic nerve

Before deciding to carry out the operation, Ian Aird's suggestion may be tried give an intravenous injection of pentothal until the patient is just unconscious. Should the hiccup return after this measure, unquestionably injection of the phrenic nerve should be undertaken.

In deciding on which side to carry out the operation one is biased in favour of the left, for that side of the diaphragm is relatively unsupported by the liver and consequently is likely to be the major offender in the spasms. However when possible, radiological assistance should be sought. By an X ray examination it is often possible to determine that the spasms are affecting one-half of the diaphragm more than the other If such evidence is definite, the more affected side should be chosen for the injection. In the absence of such evidence the left side should be chosen.

Exposure and Injection of the Phrenic Nerve.—The operation is undertaken under local anæsthesia. It is neither dangerous nor painful

The left side of the neck is chosen and the head is turned to the opposite side.

Fig 184 —The scalenus anticus and the structures in relation to it. (*After Alexander*)

The posterior border of the sternomastoid muscle is defined. A little below the junction of its upper two-thirds and lower third, a transverse incision is made. The incision should be about 2 in. (5 cm) long, and its anterior extremity lies over the posterior free edge of the sternomastoid. Beneath the platysma and the superficial layer of the deep fascia, the external jugular vein crosses the field; it should be divided between ligatures. A varying amount of fat is encountered. After suitable infiltration, this is separated by blunt dissection, initially carried out by opening the jaws of a hæmostat. The dissection proceeds behind the sternomastoid, past the internal jugular vein, which is retracted medially. Carrying the dissection deeper into the lower part of the wound, the posterior belly of the omohyoid muscle will be recognized easily. The scalenus anticus, covered by fascia, will soon become apparent in the floor of the wound, except in the very fat, in whom some further dissection will be necessary Deep to the fat lies the rather dense prevertebral fascia which covers the scalene muscles, the phrenic nerve, and the brachial plexus. These structures are only indistinctly visible through this fascia, which must be incised in order to display them clearly (*Fig* 184) The phrenic nerve and the small nerve to the subclavius are the only nerves lying on the scalenus anticus muscle *that have a medial inclination* The sympathetic trunk and the vagus nerve lie vertically and are situated nearer the middle line of the neck. The phrenic nerve is about the size of the graphite of a lead pencil. If followed upwards, its origin in several cervical branches becomes apparent. Around the nerve a ligature is placed (*Fig* 183) The nerve is then infiltrated with 1 per cent procaine solution.

Fig 185.—Exposing the left phrenic nerve

The ligature may be left in situ with advantage so that, if necessary the nerve can be reinjected, a course that in my experience has been necessary only once. Leaving the ligature hanging from the wound the skin edges are approximated. In a few instances this operation has resulted in immediate cessation of the hiccup; more often, as might be expected, the violence of the hiccup is reduced by a half or more—instead of literally hearing the nerve-racking noise down the corridor the spasms are attenuated to such a degree as to allow the patient and those about him, to rest. Within 36–48 hours the spasms have disappeared altogether in every instance.

POST OPERATIVE FLATULENCE

Flatulence occurs in some measure after most abdominal operations, and is the cause of much post-operative discomfort. Before discussing its treatment it is essential to have some knowledge of the origin of gastro-intestinal gases.

The Swallowing of Air is a normal physiological process. The gas displayed in the normal stomach by radiography is derived entirely from the atmosphere. Some of it passes through the pylorus to traverse the intestine, where it is supplemented by (*a*) interchange with the gases in the blood, and (*b*) gaseous products of bacterial activity (methane, CO_2, and hydrogen sulphide). Intestinal gas expelled per rectum is made up as follows —

70 per cent from swallowed air (N_2 and CO_2 the oxygen is absorbed in the stomach).
20 per cent from diffusion from blood.
10 per cent from bacterial activity

In health the average quantity of gas in the alimentary canal of an adult is 1 litre but the amount varies with the diet. Although gas is present throughout the gastro-intestinal tract, on X ray examination it is visualized normally only in the stomach and the large intestine, except in infancy and early childhood, when the gas in the small intestine is normally apparent also. In post-operative flatulence the source of the gas is almost entirely swallowed air

While admittedly they merge into one another two varieties of flatulence can be recognized—gastric flatulence and intestinal flatulence.

Gastric Flatulence.—Increased salivation explains most cases of undue swallowing of air and in post-operative cases excessive salivation is usually the result of nausea. Eructations that would expel gastric wind are curtailed by pain in the wound when the abdominal muscles contract. Unfortunately repeated ineffectual attempts to bring up the gas result in swallowing more air and the acute discomfort is increased.

Treatment.—The patient should be instructed not to try to bring up wind, but to allow it to come up of its own accord If there is no contra indication the following carminative can be prescribed —

℞	Aspirin	gr 15 (1 G.)
	Sod. Bicarb.	gr 30 (2 G.)
	Sal Volat.	min. 30 (2 ml.)
	Aq Menth. Pip	ad min. 240 (15 ml.)

If this is not effective within half an hour and before that time if the epigastrium is full and tympanitic, a gastric aspiration tube should be passed. The fact that more gas than fluid is aspirated settles the diagnosis, and brings relief.

Aerophagy—Excessive air swallowing is habitual in a few individuals, and on close observation it is sometimes possible to discern that they gulp air at frequent intervals. In the majority of instances this is an unconscious reflex, and if so it is useless to admonish the patient. A piece of cork held between the back teeth for half an hour after feeds or when the patient feels distended, inhibits attempts to swallow

Intestinal Flatulence.—Gas pains are due to contraction of a dilated loop on its contents. The gaseous content causing the distension is almost entirely swallowed air One should visualize the condition as being due to disordered peristalsis displacing the gas forth and back. Borborygmi can sometimes be heard by the unaided ear In other circumstances abdominal auscultation is desirable.

Treatment—To give oil of cajuput, min. 3, on a lump of sugar is quite harmless and frequently aids in expelling gas per rectum. Two teaspoonfuls of undiluted brandy in addition, gives the patient a sensation of gastric solace.

A rectal tube can be passed and left in position for upwards of an hour The best type of rectal tube for this purpose has a terminal eye, not one at the side, like a Jacques catheter If there is no contra indication, a turpentine enema sometimes gives much relief if it is not effective it must not be repeated for 24 hours. Gastric aspiration should be commenced early in severe cases and those which do not respond quickly to the above measures. Gastric aspiration especially when it is applied continuously by extracting air soon after it is swallowed, prevents aggravation of the condition; in 70 per cent of cases the tube enters the duodenum. It then removes gas from the intestine as far as the ileocecal valve conferring great benefit within a few hours. For reasons given later morphine and its derivatives should not be administered If required, pethidine or amidone are substituted.

Severe cases, especially those in which the pulse-rate is accelerated, must be watched with vigilance The girth of the abdomen should be measured and recorded, and a

two-hour pulse reading charted The constant anxiety is whether post-operative flatulence is sufficient to account for the symptoms. Is it the first stage of paralytic ileus or commencing post-operative intestinal obstruction? These are questions that one must ask oneself taking into account that the latter is most unlikely during the first three post operative days. A radiograph, especially a lateral radiograph, of the abdomen may prove helpful. If flatus is not passed within 30 hours some degree of paralytic ileus (or intestinal obstruction) must be present.

The Prevention of Post-operative Flatulence and Distension.—It is well proven that the incidence of this complication is minimized by the avoidance of pre-operative purgation by handling the intestines gently and keeping them covered and moist during the operation. Repeated injections of morphine or omnopon are likely to inhibit normal intestinal propulsion and may cause segmental tonic contraction of the small intestine Barbiturates decrease peristalsis and intestinal tone.

Favourable reports have been published on the routine use of Calcium pantothenate 50 mg. is injected intramuscularly before operation and another dose is given six hours after operation (J E. Jacques). Pantothenic acid is a component of the vitamin B complex, and is concerned in the physiological elaboration of acetylcholine which is necessary for normal contraction of involuntary muscle

Undoubtedly if nothing is given by mouth until the patient has passed flatus, while fluid balance is maintained parenterally the incidence of post-operative flatulence as well as that by acute dilatation of the stomach (see p. 204) and paralytic ileus (see p. 402) is reduced perceptibly

POST OPERATIVE RETENTION OF URINE

Post-operative retention is a somewhat common complication especially after operations for strangulated hernia and after spinal anaesthesia. When called to a patient whose abdomen is stated to be distended after an abdominal operation, remember the full bladder This advice is of great practical value.

In post-operative retention the first thing to aim at is to try to get the patient to pass urine naturally Proctoclysis definitely favours retention when the rectal tube has been removed the patient sometimes passes urine naturally

In dealing with this troublesome condition one should follow some logical therapeutic crescendo (1) If fluids by mouth are allowed, potassium acetate, which is both a para sympathetic stimulant and a diuretic, is prescribed: ½ oz. (15 ml.) of 1 : 15 solution of liquor potassii acetatis. This is repeated every half hour for eight doses if required (This drug is harmless the same cannot be said of carbachol and other preparations which belong to this group) (2) Psychological methods are tried. Assure the patient that there is no danger of organic obstruction, and suggest to him that if he cannot void urine in a given time a catheter will have to be used. (3) Hot stupes to the hypogastrium combined with supporting the lower abdomen with the flat of the hands, and in certain cases allowing the patient to put his knees over the side of the bed, or in certain cases, a male can be allowed to stand or a female can be assisted on to a commode, are the next steps to be tried (4) Catheterization: naturally discrimination must be used as to how long to persevere before the catheter is employed.

It must be remembered that patients with post-operative retention are prone to evelop cystitis and an ascending urinary infection, therefore always prescribe sulphatriad r a broad spectrum antibiotic, and continue with it until normal micturition has been tablished for three days. Should repeated catheterization be necessary and the patient a man of over fifty the possibility of an enlarged prostate should be kept in mind.

MALNUTRITION AND HYPOPROTEINÆMIA

This is a cause of many complications, including œdema of the wound and burst omen. Provided the patient is permitted oral or jejunal feeding, several surgeons have ten in praise of Varco's diet No. 2.

Whole eggs	6
Egg whites	2
Skimmed milk powder	4 oz.
Lactose	300 G
Skimmed milk	1000 G
Salt	5 G
Flavour with chocolate or vanilla syrup	

The usual diet is supplemented by this mixture, given to the patient four to six time a day in quantities of 230 ml.

Transnasal Polythene Tubing for Feeding.—The superiority of oral alimentation, whe permissible, over the intravenous route is well recognized. Fine-calibre polythene i non-irritant, and can be tolerated in the upper gastro-intestinal tract for long periods Lovelace recommends polythene tubing with an outside diameter of 2·4 mm. for thi purpose. The tube is cut to the same length as a Ryle's tube, and is passed down th nostril in the same way. It is much better to introduce the liquid nourishment into th stomach than into the duodenum or jejunum, but should it be necessary to pass the tub into the jejunum, e.g. past a duodenal fistula, a somewhat longer length of tubing is taken To pass the tube into the upper jejunum, the distal 2 in. (5 cm.) of a finger of a rubber glov is cut off, and in it is placed 5–10 ml. of mercury. The mouth of the finger-cot is tied securel by the end of a long piece of silk. The bag containing the mercury is passed down th nostril in the same way as a Miller Abbott tube. When a radiograph shows that the ba has entered the jejunum, the polythene tubing is threaded on the silk and passed onward until its tip reaches the neck of the bag. The silk is then cut, and together with the ba in due course it is passed per rectum. Watery fluids can be gravitated through the tub by the drip method. To introduce fluid of a thicker formula through this fine tubing a syringe or a mechanical pump must be used. By way of the tube up to 6000 calories a day can be given, and it is possible to increase the patient's weight by as much as 1 lb (0·455 kg.) a day for three weeks.

STITCH ABSCESS

Stitch abscess may or may not be due to the use of imperfectly sterilized sutur material. When more than one isolated case occurs, samples of the suture material employed should be sent for bacteriological examination. On one occasion, after prolonged investigation, an epidemic of stitch abscesses was traced to infected powder used with rubber gloves.

Except for some such definite purpose as withdrawal of a drain, the wound should not be uncovered until the time has arrived for the stitches to be removed. This rule is broken only if the patient complains of more pain in the area than is to be expected and/or there is pyrexia to be accounted for. During the first three or four days after operation these pointers are likely to be caused by a hæmatoma of the wound, which must be evacuated. Often mere inspection of the wound in the early stages reveals nothing. When it is necessary to exclude hæmatoma formation or infection of the wound, the surgeon or his deputy, masked, gowned, and gloved, should gently but systematically palpate the area. Induration and tenderness will be found in this way perhaps two or three days before œdema and redness become manifest. One stitch nearest the indurated area is removed. In the event of purulent fluid being evacuated, a specimen is sent for culture and sensitivity of the causative organism to antibiotics. While awaiting the report, penicillin is given systemically. A dry dressing is applied; fomentations are not recommended. If no pus is evacuated, and on the following day the condition is *in statu quo*, a sterile probe can be used to separate the skin edges over a minute area where pus (or blood) is thought to be present.

If redness is observed near some part of the incision, laparotomy corsets should be applied.

When a sinus continues to discharge for more than ten days, it is probable that there is an unabsorbable stitch (if this material has been used) keeping up the infection. The best means of ascertaining this point is to pass a fine crochet hook to the bottom of the sinus so lightly that it proceeds almost under its own weight. If a stitch is present it is often possible to catch it in the hook, and if loose, it comes away with a slight pull. When this manœuvre is not fruitful it can be repeated in a day or two. After one or more infected stitches have been removed, prompt healing is the rule.

BED-SORES

Bed-sores can be divided into three classes (or stages): (*a*) Threatened. (*b*) Early. (*c*) Established (ulcer). Prevention, if thought of in time, is often comparatively easy; treatment is difficult.

PREVENTION

Dr. Bernard Fantus, Director of Therapeutics at the 3400-bedded Cook County Hospital, Chicago, considers "that a physician who does not on his daily round examine

the backs of patients who are especially predisposed to bed-sores is remiss in his duty" All patients who are confined to bed must receive special nursing and medical attention that includes frequent changes in position (at least five times a day), adequate nutrition, measures for maintaining a dry bed with sheets free from creases, and routine treatment to prevent chafing the skin over the lower part of the sacrum. Threatened areas should be massaged. A sorbo rubber mattress is a great help.

A pneumatic mattress with parallel rows of air cells arranged longitudinally and in which alternate rows are filled and emptied by a small electric pump, has proved revolutionary in the prevention as well as the treatment of bed-sores at the Cleveland Clinic Hospital. The mattress is comparatively thin, and laid on the ordinary mattress. Its constant undulating movement prevents pressure at any given point for more than 30 seconds, and its action may be described as one of massage, which is known to enhance the blood-supply to the skin (Gardner).

Fig. 186.—Adhesive plaster applied as a preventive measure for bed-sore

Barrier-cream Technique.—Instead of the time-honoured washing with soap and water followed by rubbing with spirit and powdering, the régime about to be described is far more effective. The part is washed with warm water only and dried carefully. Silicone vasogen (lactogol) barrier-cream is smeared thinly and evenly over pressure areas twice daily for a week, and thereafter once daily. Washing does not remove the barrier-cream that has been applied. The patient is given tolazoline, 25 mg t.d.s. and vitamin C 50 mg t.d.s. Tolazoline is administered in the endeavour to enhance the blood-supply to the skin.

Flexible Adhesive Plaster as a preventive measure is a well-tried method. The skin is washed, swabbed with alcohol, painted with tinct. benzoin. co., and the flexible plaster is laid on perfectly evenly over the sacrum (*Fig* 186) and the heels. It is of paramount importance that the plaster be applied with skill and care. It must neither be too tight nor must it wrinkle. If the plaster is allowed to wrinkle it will probably do more harm than good.

TREATMENT OF AN ESTABLISHED BED-SORE

In all cases a culture is taken from the floor of the bed-sore, and while awaiting the bacteriological report penicillin is administered, and continued unless the sensitivity tests dictate otherwise. It is important to correct anæmia, hypoproteinæmia, or avitaminosis, if any of these are present.

Tulle Gras Dressings.—When the patient can be allowed up a small clean bed-sore often heals fairly quickly under tulle gras dressings.

Local Insulin Treatment.—Recently it has been found that 20 units of insulin squirted into various parts of the wound two or three times a day has an astonishingly beneficial effect. When the edges of the sore are comparatively insensitive a little of the insulin can be injected into the extreme edge therein. The method is empirical.

Proteolytic Débridement.—If as is frequently the case, the floor of the bed-sore is occupied by a slough, the first duty is to obtain a clean granulating surface, without which none of the measures to protect the area from further trauma will result in healing. The only expeditious method of safely removing the slough is by proteolytic débridement (*see* p. 140).

Treatment with Ambrine Wax (a latex-containing hard paraffin wax) has been found effective in many hospitals.

To melt the Wax.—Place a bowl containing the wax in a saucepan half full of water and bring the water to the boil. When the wax is molten take the saucepan and its contents to the bedside; wait until a skin commences to form upon the surface of the wax. The temperature is then correct for application. Keep the bowl in the hot water while applying the wax, but on no account allow hot water to get into the wax or a burn may result.

Method of Application.—The ulcer is washed as clean as possible with normal saline solution. (1) Melted wax is brushed gently on the bed-sore or a special heated spray can

be employed. (2) A layer of cotton wool, teased almost to the thinness of a spider's web, is laid upon the wax. (3) A second application of wax covers the wool. (4) Another layer of wool is laid upon the wax, followed by (5) A final application of wax.

The wool acts in the same way as wire mesh in concrete, and prevents cracking.

Removal of the Dressing is undertaken 10 to 14 days later when it will be found that it can be lifted off without tearing granulations, and therefore no bleeding occurs. An exudate which can be washed away with saline solution, covers a clean granulating surface. As a rule one or more further applications, or skin grafting will be required.

Skin-grafting.—Once a clean granulating surface has been obtained the application of split-skin grafts will expedite healing.

Excision and Closure.—In cases of very large bed-sores when the patient's general condition has improved, excision of the ulcer and closure in the manner shown in *Figs.* 187 188 greatly expedite healing. The sores that require surgical repair are those over the tuber ischii the greater trochanter and the sacrum, in that order.

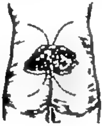

Fig 187.—Bed-sore excised showing flaps which are undercut.

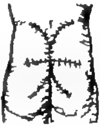

Fig 188.—Closure completed.

Sores over the Tuber Ischii.—The paraplegic spends more of his waking hours sitting in a wheeled chair than any other position; consequently pressure sores are very liable to develop over the tuber ischii. When no improvement occurs after a month of conservative treatment, excision of the sore and covering the area with flaps should be carried out.

Acute Dilatation of the Stomach, *see* p. 204
Paralytic Ileus, *see* p. 402.
Post-operative Intestinal Obstruction, *see* p. 422.
Burst Abdomen, *see* p. 107
Fæcal Fistula, *see* p. 529
Phlebothrombosis Decubiti, *see* p. 925

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CHAPTER XI

LAPAROTOMY

Anyone who opens the abdomen should be capable of dealing with any condition he may find there (Sherren.)

EXPLORATORY LAPAROTOMY

A CORRECT diagnosis is the handmaiden of a successful operation. If on opening the abdomen we find what we expect, the operation is more likely to proceed smoothly and on the whole it is bound to be done better Atypical cases still provide a number of

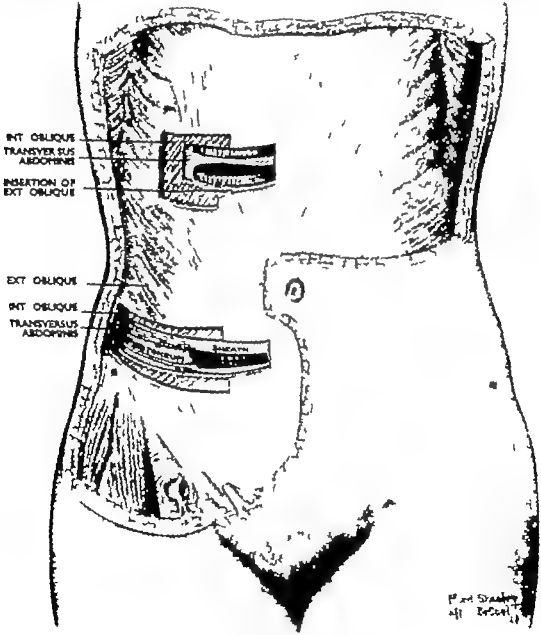


Fig 188.—The anatomy of the abdominal wall, with special reference to the disposition of muscles encountered in the various abdominal incisions described in this work.

instances where an exploratory operation is the only course. We should, however always strive our utmost to arrive at a pre-operative diagnosis. In cases of doubt a fundamental principle is to try to decide whether the upper or lower abdomen has to be opened—not always an easy matter

If the abdomen has been opened in an unsuitable place, there are two possible courses to pursue (1) To prolong the incision into the region of the lesion (2) To close the incision and reopen the abdomen elsewhere. Usually two small incisions are preferable to one large one for the following reasons: (a) A large incision is difficult to sew up unless the anæsthesia is perfect and there is no intestinal distension (b) With an extended incision infection is liable to be distributed, especially from the lower to the upper abdomen (c) If wound infection follows, the larger the incision the greater are its attendant dangers.

Throughout the succeeding chapters reference will be made to particular incisions. *Fig* 189 shows the relevant muscles. To commence with, it will be convenient to describe a standard method of opening and closing (a) the upper and (b) the lower abdomen.

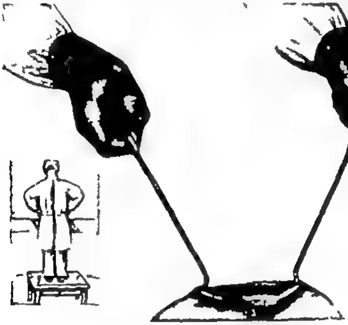


Fig 190.—Wound hooks in action. The inset shows the assistant standing on a stool, whereby the hooks can be supported with less fatigue.

The Upper Abdomen: The Midline Incision.—When the lesion is situated in the upper abdomen the *midline incision has much to offer* By employing this incision the abdomen is opened readily and, what is more important, it is closed easily The path traversed by the incision is practically avascular Furthermore, the incision can be enlarged quickly The incidence of post-operative hernia is not greater than that following most incisions.

Midway between the ensiform process and the umbilicus, exactly in the middle line an incision about three inches (7 5 cm) long is made—it need not be longer for it can be enlarged upwards or downwards as circumstances demand. Towels are clipped to the skin edges in such a manner as to hide the clip beneath the towel. It is advantageous in the long run not to clip the towels at the extremities of the wound until it is ascertained that the length of the incision is adequate. The incision is deepened and the aponeurosis cut through. The aponeurosis is composed of white fibrous tissue and practically no bleeding occurs The peritoneum is opened in the lower third of the incision, and *slightly* to one side of the midline, the better to avoid entering the layers of the falciform ligament. The opening in the peritoneum is then extended upwards and downwards within the limits of the incision.

Closing the Incision—Wound hooks are placed in the extremities of the incision (*Fig* 190). These are lifted by the assistant, who will find it convenient to stand on a stool, for traction has to be maintained until the incision is closed. These hooks dispense with the necessity of placing forceps on the edges of the peritoneum. Silkworm gut sutures are passed at intervals of about three-quarters of an inch (2 cm.) on a large cutting needle. These sutures traverse all layers, and, having been passed, their free ends ar

clipped independently in hæmostats. The aponeurosis is approximated by a continuous catgut suture, a moderate-sized curved cutting needle being used for the purpose (*Fig* 191). After this layer has been closed the through and through sutures are tied firmly but not too tightly (*Fig* 192). *Not until this stage has been completed are the hooks removed* nor is the upward tension on them slackened, for without their aid there is a danger of a

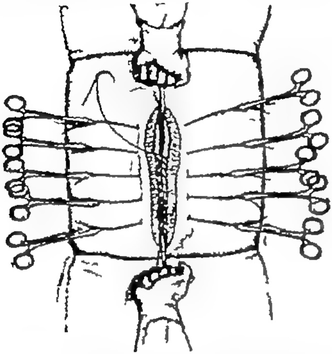


Fig 191.—Closing the midline upper abdominal incision.

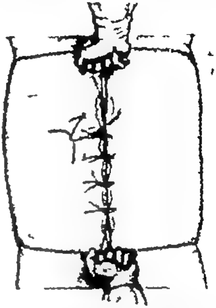


Fig 192.—Closing the midline upper abdominal incision. The last through-and-through suture is being tied. The hooks are then removed, and a few skin sutures complete the closure

loop of intestine being ensnared under a deep suture. Once the last deep suture has been tied the hooks are removed. The skin edges are then brought together by fine interrupted sutures between the deep stitches. The through-and-through sutures should be left in for thirteen or fourteen days. I have opened and closed the upper abdomen in this manner hundreds of times, and can recommend it unhesitatingly.

The Lower Abdomen: The Paramedian Incision.—The midline incision, so efficient in the upper abdomen, cannot be recommended in the lower. A strictly median incision below the umbilicus is very prone to give rise to a post-operative hernia, which is associated with the largest incidence of strangulation: therefore the right (or in selected cases, a left) paramedian incision is used.

An incision about five inches (12.5 cm.) long and one inch (2.5 cm.) from the middle line is made. Bleeding points are secured. Towels are clipped to the skin edges. The rectus sheath is incised within the limits of the incision. Hæmostats secure the medial cut edge of the sheath. The muscle is dissected out of its bed and retracted laterally (*Fig* 193). The peritoneum is opened.

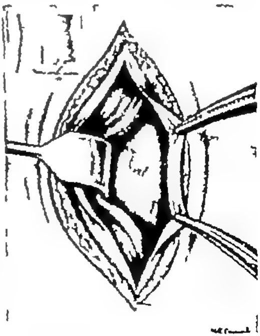


Fig 193.—*The right lower paramedian incision.*

Alternative Procedure.—Instead of the rectus muscle being mobilized and retracted, it can be split vertically. Quick and efficient, this is most valuable in emergency operations. Whether the rectus muscle is split or retracted, bleeding from muscle is best arrested by under running the mouth of the open

vessel with a ligature on a needle I do not apply hæmostats to muscle. In the case of the split rectus bleeding usually comes from the free edge of the muscle and it can be dealt with neatly by an X-shaped stitch as shown in *Fig* 194

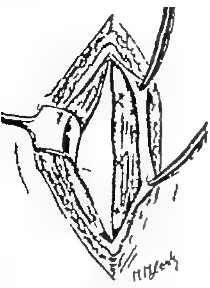


Fig 194 —The split rectus incision. Note that the method of under running bleeding points with a ligature on a needle has been employed.

A Method of Opening the Peritoneum applicable to all Incisions.—Wounding an underlying structure whilst opening the peritoneum is an error not infrequently committed by the beginner The following method guards against this possible danger The peritoneum having been displayed, it is picked up in dissecting forceps and elevated. With a little shake imparted to the instrument any structure lying hard up against the under surface of the peritoneum is likely to be disengaged. A hæmostat is applied to the pinched-up fold. The dissecting forceps are then momentarily removed, and the fold is shaken again by the hæmostat. The dissecting forceps once more pick up the elevated peritoneum at a convenient point near the hæmostat, which is handed to an assistant. Holding a scalpel nearly horizontally the peritoneum is incised (*Fig* 195).

A Method of Enlarging an Opening into the Peritoneum —First the opening in the peritoneum is enlarged in an upward direction with scissors. It is then enlarged downwards in the following manner the separated index and middle fingers are directed downwards beneath the peritoneum, which is severed with the scalpel deliberately (*Fig* 196).

Closing the Lower Paramedian Incision —Long hæmostats grasp the cut edge of the peritoneum. There should be forceps on each extremity and two on each side The forceps on the extreme upper end should take a large bite of tissue so that the assistant can exert some upward traction

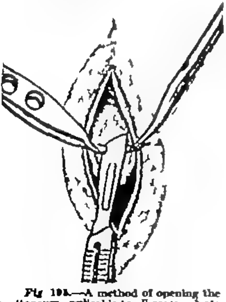


Fig 195.—A method of opening the peritoneum applicable to all cases. Note that the scalpel is held practically flat.

Fig 196.—Enlarging the opening into the peritoneum in the downward direction.

in this direction. When difficulty is experienced in approximating the peritoneum in spi of this traction, Sargent s depressor or better a McNealy's rubber guard, is useful in keepi back unruly coils. When great difficulty is encountered in this respect, an abdominal pa

is introduced and Sargent's depressor applied over this. Commence by sewing up the inferior end of the incision. If the peritoneum is holding well an over-and-over stitch is used. If the stitches tend to cut out a large bite is taken on the under surface of the peritoneum parallel to its cut surface (*Fig.* 197). The lower part of the incision is usually the most difficult to close. As soon as we have got above the linea semilunaris, the peritoneal layer will nearly always hold its stitches.

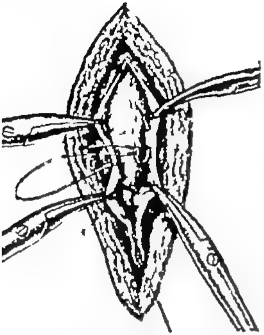


Fig. 197.—Approximating the cut edge of the peritoneum in cases of difficulty. A bit is taken with the needle on the under surface parallel to the cut edge.

Closing the Peritoneum (applicable to all cases, unless stated otherwise).—When the edges of the peritoneum do not come together kindly it is best to resort at once to interrupted stitches. In cases of real difficulty (the patient is straining or the intestines are distended or both) Ward's rolling stitch can be recommended. The virtue of this stitch is that the peritoneum is rolled on itself several times, giving a reinforced edge through which sutures will not tear out so readily. The stitch is difficult to describe, but easy of application. *Fig.* 198 should make the procedure clear. The stitch is passed into the wound and out through the rectus muscle or its sheath on the proximal side; into the wound and out through the rectus muscle or its sheath on the distal side; into the wound and out through the peritoneum on the distal side and then tied. In cases of exceptional difficulty it is advantageous to pass two or even three of these stitches before tying any of them.

Fig. 198.—Ward's rolling stitch.

In order that the operator may become familiar with the stitch, and thus be able to apply it expeditiously, it is desirable to practise it in cases where it is not essential; as it is an excellent general purpose stitch, there can be no possible objection to this recommendation.

The Gridiron Incision.—

Indications.—(1) It is the best incision for the removal of an acutely inflamed appendix. (2) It is occasionally of value as an avenue of approach in an acute abdominal catastrophe of uncertain origin. If unsuitable, the incision is closed readily.

Far be it that we should be cramped for room. The reverse is the case; but in the first instance the incision should be small. It can always be enlarged if necessary. Enlargement should be undertaken at the very first sign of difficulty, for the opening must be of sufficient dimensions for the appendix to be removed without dragging and pulling.

The incision is made at right angles to a line joining the anterior superior iliac spine to the umbilicus, rather nearer the former than the latter. The classical site for the incision (*Fig.* 199) may with advantage be subjected to a certain degree of variation. Thus, if on palpating the right iliac fossa under the anæsthetic (a step which should never be omitted when this incision is contemplated) the appendix, or omentum which surrounds it, can be felt, the incision is made over the centre of the lump. Again, if the appendix is judged to be retrocæcal, the incision is made a little higher and a little nearer the flank; and so on.

The skin having been incised and bleeding points ligated, towels are clipped to the wound edges. The external oblique aponeurosis and muscle, should any lie within the limits of the incision, are incised in the direction of their fibres. A long hæmostat picks up the medial cut edge, and a curved retractor is placed under the lateral margin. The

assistant holds the hæmostat in his left hand and the retractor in his right. The internal oblique is now divided in the direction of its fibres the scalpel is held with its blade towards the middle line, and the superficial part of the muscle in the outer part of the wound is divided. The remainder of the muscle is split with the handle of the scalpel working in conjunction with the left forefinger One burrows in this manner through the transversus abdominis also. As soon as the peritoneum is reached, the scalpel is laid aside and the split is made more complete by stretching the wound with the forefingers

Fig 199 —The classical site for a gridiron incision is over McBurney point. McBurney's point lies upon the line shown 1½ in. (3 75 cm.) from the anterior superior iliac spine. This point is often incorrectly given more medially

after the retractor has been removed. A pair of curved retractors is placed under the split transversus abdominis, and after displacing the extraperitoneal fat with a Lahey's swab (*see Fig* 12) the peritoneum is picked up and incised in the manner described already (*see Fig* 195). Once the peritoneum has been nicked, the opening is enlarged by stretching it with the handle of the scalpel and the forefinger This method gives a circular hole which can be encircled with a purse-string suture when the time comes for the incision to be closed.

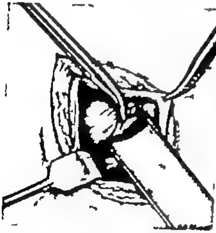


Fig 200 —Enlargement of the gridiron incision. The internal oblique is detached from its insertion into the rectus sheath. A Sargent's depressor is used to protect underlying structures.

Finally an excellent expedient is to pass the curved retractor under the peritoneum on the medial side and give the handle to the assistant to hold directly upwards (*see Fig* 282). Thus the abdominal wall is lifted up whilst the surgeon peers into the wound to locate the cæcum and incidentally notes anything else he finds, particularly the amount and character of the peritoneal exudate.

Closing the Gridiron Incision —The edges of the peritoneum are picked up in hæmostats, and a purse-string suture is inserted and tied, thereby closing the peritoneum with a minimum amount of catgut. The edges of the split internal oblique and the transversus abdominis are approximated by a single catgut stitch applied in the form of an X, or two interrupted cotton sutures. Two interrupted stitches bring together the external oblique aponeurosis, and there remains only the skin to be stitched up. A glove drain under the skin is advisable in all except very early cases of acute appendicitis where the disease is confined to the mucosa.

Enlarging the Gridiron Incision.—If one is simply hampered for space in which to deliver the cæcum, the skin and external oblique are divided still further after which the internal oblique can be split more completely and a limited degree of space is added to the incision

What is more important is to have at one's command a method of extending the incision in order to trace an anomalous appendix upwards or downwards. More often it is in the upward direction that we have to follow the organ

A Method of Gaining More Room in an Upward Direction —The skin and external oblique incision may be extended in an upward direction. This is not always necessary and if it is judged that only a moderate amount of extra room will be required this step is deferred

The medial cut edge of the external oblique is picked up in a hæmostat and retracted. A little blunt dissection between the external and internal obliques renders the insertion of the internal oblique into the rectus sheath demonstrable This junction must be seen clearly The narrow end of a Sargent's depressor concave surface uppermost, is slipped under the peritoneum, and after peering along its surface in order to make quite certain that no structure intervenes, the internal oblique is severed from the rectus sheath and the underlying peritoneum likewise divided (*Fig* 200). Usually a vessel requires attention on the medial aspect this is whipped over with a needle carrying a ligature When using this method it is surprising what a gain in space attends a prolongation of even one inch (2 5 cm)

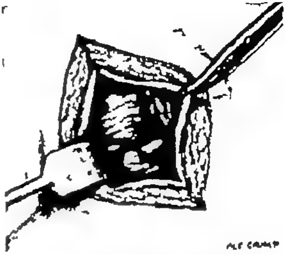


Fig 201 —The repair of the prolonged gridiron incision. When the suturing is completed, the suture line resembles a reversed L.

Closing the Extension —A purse-string suture, so useful for closing the peritoneum in the case of an ordinary gridiron incision, cannot be recommended when that incision has been extended. The peritoneum should be closed after the manner which is usual in a laparotomy incision. The apex of the ⅃-shaped incision is picked up in a hæmostat, and this corner is sewn on to the rectus sheath opposite the split internal oblique. Interrupted sutures complete the repair which when finished forms a neat ⅃ (*Fig* 201) The rest of the incision is closed in the usual manner

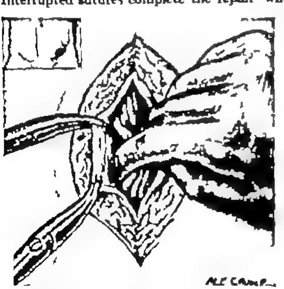


Fig 202.—Battle's incision. The rectus sheath has been opened, and the muscle is retracted medially by the assistant's forefinger Metal retractors are liable to injure the inferior epigastric vessels.

Extension in a Downward Direction —If more room is required in the downward direction exactly the same principle is adopted with that part of the internal oblique which lies below the split in its fibres.

I have carried out the ⅃-shaped extension of the gridiron incision in over 400 cases. The incidence of post-operative hernia is almost negligible, and has only occurred in those cases in which prolonged suppuration has ensued. In two of these a secondary operation for the repair of the hernia had to be undertaken, and the reconstitution of the abdominal wall proved to be simple

Battle's Incision.—

Indications —(1) Pelvic appendicitis, particularly in women where disease of the adnexa cannot be excluded (2) A similar incision to Battle's incision only on the left side is used when perforated diverticulum of the colon is suspected

An incision about three inches (7 5 cm.) long is made a little to the lateral side of the middle of the right rectus muscle After towels have been clipped to the wound edges the incision is deepened and the rectus sheath is opened in the length of the incision. Hæmostats are placed on the lateral cut edge of the sheath, and the muscle is mobil-

medially. Any bleeding points in the muscle are whipped over with a ligature on a round-bodied needle. The assistant then draws the belly of the muscle to the left. This necessary retraction is performed preferably with the crooked index finger (*Fig.* 202), for metal retractors tend to wound the deep epigastric vein and cause troublesome bleeding. The inferior epigastric vessels are rather a bugbear and certainly constitute a main disadvantage of this incision. If, however, the finger is used as a retractor they usually escape injury. The peritoneum is opened rather nearer the inferior end of the incision, the better to avoid two small nerves and the vessel which pass into the deep surface of the muscle. An endeavour to preserve nerves should be made, but they must often be divided or break when the intra-abdominal manipulations prove troublesome. I have been unable to satisfy myself that any harm results from the dissolution of their continuity.

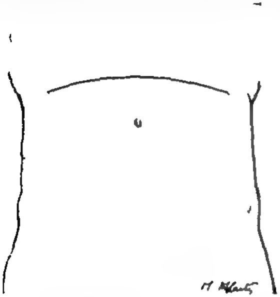


Fig. 203.—The transverse upper abdominal incision.

Repair of the Incision.—Is carried out *in precisely the same manner as the lower paramedian incision*—to wit, the peritoneum is sewn up, through-and-through sutures are placed through the skin and under the rectus sheath (usually one suffices), the rectus sheath is drawn together with interrupted catgut sutures, after which the skin is approximated.

The Transverse Upper Abdominal Incision, extending over one rectus abdominis only, is recommended when operation becomes necessary in a case of acute cholecystitis. It can also be used for splenectomy in cases of rupture of the spleen when the diagnosis is certain. If necessary, the incision can be extended across the abdomen, e.g., to repair a rupture of the liver. The incision passes across the chosen half of the abdomen at the level of the 9th costal cartilage (*Fig.* 203). The rectus sheath is divided in the length of the incision, and the rectus muscle likewise divided. This can be carried out by a

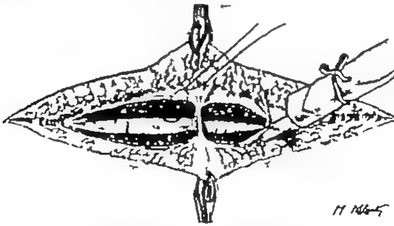


Fig. 204.—Dividing the rectus muscles with the diathermy needle. The method of occluding a bleeding point with a stitch is also shown.

diathermy needle (*Fig.* 204). It will be found that when the muscle-fibres are cut across, the rectus muscle does not retract within its sheath; the tendinous intersections prevent retraction. The vascularity of the rectus abdominis varies within wide limits. Sometimes there is hardly any bleeding at all; at other times numerous stitches have to be inserted. It is most desirable not to try to pick up bleeding vessels with a hæmostat, for this crushes and tears muscle-fibres, and often an ordinary ligature cuts through. *If the* bleeding point is under run with a needle which at the same time traverses the edge of

the rectus sheath haemorrhage is controlled effectively. When haemostasis is assured the rectus abdominis is severed completely. The posterior rectus sheath and the peritoneum are incised. If the incision passes across the middle line the ligamentum teres will need division between ligatures.

Closing the Incision.—The posterior layer of the rectus sheath with the peritoneum can be approximated easily. No attempt should be made to approximate the muscle

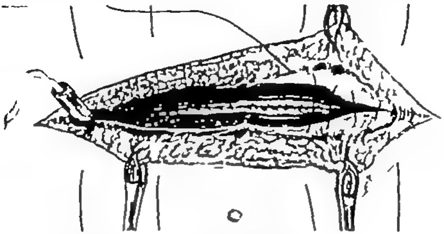


Fig. 205.—Transverse incision. Closing the anterior rectus sheath. When this layer is approximated accurately the cut muscle-fibres will be in apposition.

The next layer that requires suture is the anterior rectus sheath; this can be accomplished by a continuous (*Fig.* 205) or more usually with interrupted sutures. Tension sutures are inserted. The skin incision is closed by interrupted stitches.

The Transverse Lower Abdominal Incision.—Is favoured by some surgeons. They regard this as an extremely good approach when the diagnosis of acute appendicitis is suspected but some other lesion in the lower abdomen cannot be excluded. The incision

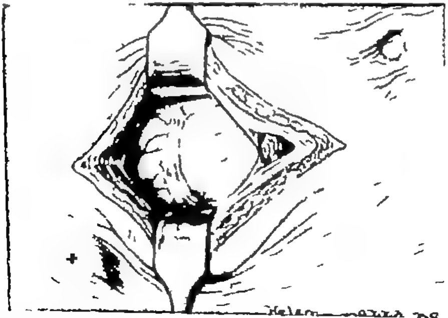


Fig. 206.—The transverse lower abdominal incision.

is made 1½ in. (3.8 cm.) above the anterior superior iliac spine and extends to the edge of the rectus sheath. The external oblique is divided in the line of the skin incision and so is the fleshy internal oblique. The peritoneum is opened (*Fig.* 206). The advantage of this incision is that if more room is required, the rectus sheath is opened

by extending the incision medially and the rectus muscle can be retracted, givin
exposure.

Repair of the Incision.—The incision is closed in layers. It is necessary to
the internal oblique with more than usual care, using interrupted sutures.

Fig. 207.—Method of attaching stainless steel wire to a needle by means of a length of silk tied with a reef knot.

Closing Abdominal Incisions with Stainless Steel Wire.—Stainless steel alloy wire S.W.G. 31 is employed. It is strong and supple, but there are two fundamental principles in its use: (*a*) Stainless steel sutures must be placed in the tissues without tension; (*b*) The wire must never be kinked, or it will break at the kink.

Ordinary needles can be used; the best method of attaching the needle to the wire is shown in *Fig.* 207. It can also be attached by being threaded through the eye and a short length twisted several times on itself. The wire can be purchased with eyeless needles attached, but the wire is liable to fracture at the join.

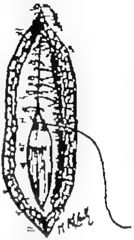
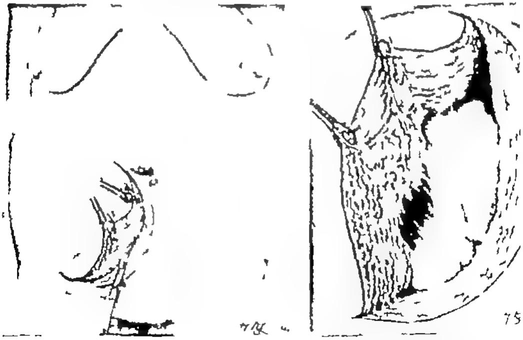


Fig. 208.—Closure paramedian incision with less steel wire using th and near stitch. (*After Ab Hunt.*)

Technique.—The peritoneal coat is sutured with catgut or cotton in the usual m
Taking, for example, the paramedian incision, it is the anterior rectus sheath that is



A B

Fig. 209.—A, B, By raising a suitable flap, the musculature of the abdominal wall can be freely exposed, even when 6 in. or 8 in. (15 or 20 cm.) of subcutaneous fat intervene.

with the wire. Commencing above, the first stitch is passed through the tissues, a
wire is tied in a reef knot. The short end is gripped against the knot with a hem
and cut close to the jaws. It is advisable to use an old pair of scissors for this pu

Throughout the insertion of the suture the assistant holds the wire in a loose, open loop, using both hands. As the needle is passed through the tissues he allows the wire to follow without tension, and catches it again as it is drawn out. By this means kinking is prevented. A good method of suture is to employ the far and near (i.e. figure-of 8) stitch (*Fig* 208). Each far stitch is passed through the anterior rectus sheath and the muscle about 1 cm. from the line of section, and is brought out of the incision to take a near bite of the rectus sheath only. It is highly important that the stitch should be pulled no tighter than just sufficient to draw the cut edges together. At the lower end of the incision the suture is finished off by knotting in the same manner as it was commenced.

Stainless steel wire is used by a number of surgeons as a routine method for closing the abdominal wall. It certainly has much to offer in infected cases. Stainless steel cannot harbour micro-organisms, and granulation proceeds in its presence. The wire is sterilized by heat, and there is no risk of it introducing infection.

LAPAROTOMY IN THE IMMENSELY OBESE

These remarks concern laparotomy upon patients with rolls of fat in the subcutis of the abdominal wall. As often as not and particularly when the patient is young, the abdominal musculature beneath this excessive fat is normal. A standard incision when made through six or eight inches (15 or 20 cm.) of subcutaneous fat causes the operator to be hampered by meagre exposure in the depths of the wound. Hilton Parry's suggestion is of considerable practical value. He advises that the appropriate area of the underlying abdominal musculature be laid bare by raising a flap which can be varied to suit particular circumstances. *Fig* 209 A and B show a flap suitable for exposing the aponeurosis of the external oblique of the lower right quadrant. It enables the operator to proceed with a lower paramedian incision, a Battle's incision, or a gridiron incision without hindrance. At the conclusion of the operation it is usually advisable to leave a corrugated rubber drainage tube through the dependent part of the incision for 48 hours for fat laden subcutaneous tissue is prone to become infected at the least provocation.

Thoraco-laparotomy.—*See* p. 808

A GUIDE TO THE STUDY OF PERITONEAL EXUDATES

The abdomen is a temple of surprise and it is only by experience that we learn to come to a conclusion quickly as to how to proceed when as the result of laparotomy intraperitoneal findings are at variance with pre-operative expectation. Amongst the most valuable guides to intraperitoneal pathology is the nature of the peritoneal exudate. The emergency surgeon is advised to take every opportunity to study these exudates by sight and smell. He is further advised to arm himself with a sterile fountain-pen filler. Much instruction and little waste of time will accrue from compressing the teat and filling the barrel (*Fig* 210). Macroscopical characters of fluid become more apparent when viewed through glass. After the operation it is of the utmost importance to send this specimen of the exudate to the bacteriological department. It is much better than a swab. As the result of the bacteriological examination the surgeon will learn that sometimes the turbid fluid he considered to be pus is sterile—it is, in fact, a suspension of leucocytes; that at others, faintly opalescent fluid is full of organisms. The bacteriological study of peritoneal exudates is of abiding interest, and frequently it proves to be of great advantage to the patient in that, as a result of sensitivity tests of the organisms to antibiotics, if necessary the antibiotic in use can be changed to one best suited to overcome the infection.

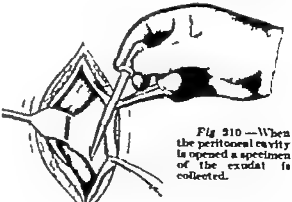


Fig 210.—When the peritoneal cavity is opened a specimen of the exudate is collected.

The following table is a guide to the quick macroscopical appreciation of possible conditions associated with particular exudates.

PERITONEAL EXUDATES

Odourless purulent fluid	Perforated peptic ulcer Unperforated acute appendicitis Salpingitis Suppurating mesenteric lymph-nodes Early cases of diverticulitis with a minute perforation Pneumococcal peritonitis (soapy)
Purulent fluid with odour[1]	Perforated appendicitis Perforated colonic diverticulitis *Perforated Meckel's diverticulum* Other rarer perforation of the lower ileum or large bowel (e.g., perforation by a foreign body)
Bile-stained fluid (no trauma)	Perforated duodenal ulcer Perforation of the gall-bladder Perforation of a bile-duct Spontaneous bile peritonitis
Blood stained fluid (no trauma)	Acute pancreatitis (look for fat necrosis) Primary streptococcal peritonitis Mesenteric embolism (musty odour) Very acute intestinal obstruction by a band Torsion of some intraperitoneal structure (i.e., torsion of ovarian cyst torsion of the omentum)
Blood (no trauma)	Ruptured ectopic gestation Ruptured lutein cyst Spontaneous rupture of the spleen Rupture of an aneurysm (e.g., of the splenic artery)
Chocolate-coloured fluid	*Thin*: Volvulus of pelvic colon; Necrobiosis of uterine fibroid (fishy odour) *Thick*—Ruptured chocolate cyst of ovary
Clear straw-coloured fluid	Intestinal obstruction Inflammatory lesions of the mucosa not requiring laparotomy (i.e., gastro-enteritis) Tuberculous peritonitis
Clear sticky fluid, curiously tinged often dark green	Ruptured ovarian cyst
Porridge-like material	Ruptured dermoid cyst: of ovary; of mesentery
Crystal-clear fluid	Ruptured hydatid cyst

Of necessity this table is incomplete. From time to time the findings are biza
I have encountered beer (perforated gastric ulcer patient inebriated, but with obvi
peritonitis) urine (spontaneous rupture of the bladder) and, on a number of occasio
a considerable quantity of faeces, but no useful purpose is served by encumbering t
table with oddities which must be recognized and dealt with on common-sense principl

When it is possible (and usually it is impossible) to have there and then in the operat
theatre the result of a microscopical examination of a stained specimen of the periton
exudate, not only can the diagnosis of primary peritonitis be made with assurance t
the difficulties and complexities of when and when not to drain the peritoneal cav
(this will be considered in *Chapter XVIII) would disappear* like dew before the sun.

[1] The foul odour of peritoneal exudate is often due to gas-forming anaerobic streptococci, a
not to *Esch. coli* as so many believe.

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CHAPTER XVI

BURST ABDOMEN

DISRUPTION of the sutured abdominal wound occurs in at least 1 per cent of emergency laparotomy incisions, excluding gridiron incisions, which are practically immune. In a recent series of 1000 laparotomies analysed by H. L. Marsh et al. the incidence of dehiscence of all layers of the wound, including the peritoneum, was 3·7 per cent. If urgent paramedian laparotomies for an infected focus (perforated peptic ulcer, perforated appendicitis, etc.) are alone considered, the incidence was no less than 10 per cent.

Surprisingly, analyses of large series of cases show that the accident is not related to the suture material employed. For instance, the incidence is not lower in incisions closed by stainless steel wire than in those sutured with catgut (Tweedie and Long; Joergenson and Smith).

Time of the Disruption.—Twenty-four per cent of cases occur between the second and the fifth days after operation; 55 per cent between the sixth and the ninth days; the remaining 21 per cent on or after the tenth day (*Fig.* 211).

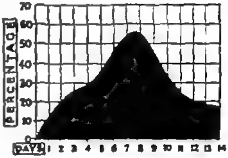


Fig. 211.—Time of disruption of the abdominal incision (Tweedie and Long's statistics).

Predisposing Causes.—

1. Hasty closure (from necessity).
2. Inaccurate apposition of the peritoneum.
3. Too early removal of tension sutures, which should remain in place for at least ten days.
4. Violent or persistent cough. Cough was a distressing symptom in a little less than half the cases (Joergenson and Smith).
5. Intestinal obstruction with distension.
6. Repeated vomiting (which should not be allowed to occur).
7. Persistent hiccup.
8. Infection of the wound.
9. Escaping pancreatic ferments.
10. Ascites.
11. Almost of equal importance are factors that retard wound healing. (*a*) Undernourishment, anæmia, advanced years, and malignant disease. (*b*) A significant proportion of patients in whom disruption occurs have a low plasma protein level, and particularly a low serum-albumin level. (*c*) Vitamin-C deficiency definitely favours disruption, as this vitamin is essential for the formation of collagen in tissue repair.
12. In most cases dehiscence of the deeper layers occurs some days before the wound actually bursts asunder. Indeed, it is probable that one or more of the peritoneal stitches snap or become untied within the first three days of operation. Sometimes the damage is done while the patient is coming round from the anæsthetic. A most potent factor in this respect is the violent coughing reflex set up if an endotracheal tube is withdrawn while the patient is but lightly anæsthetized.

Premonitory and Other Signs.—An otherwise unexplained copious serosanguineous (pink) discharge from the wound is a forerunner of a burst abdomen in fully 50 per cent of cases. It is the most pathognomonic sign of impending wound disruption, and it signifies that intraperitoneal contents are lying extraperitoneally. When such a discharge occurs, the surgeon or his deputy should put on sterile gloves and palpate the immediate neighbourhood of the incision with great care. If a localized swelling can be felt, or a dehiscence detected in the deeper planes (especially when the abdominal musculature is rendered tense), arrangements should be made for the patient to be taken to the operating theatre for examination of the wound under anæsthesia.

In 50 per cent of cases the tell tale serosanguineous discharge is absent, and the disruption occurs without warning So it comes about that burst abdomens are of two varieties the surgeon is summoned hastily because the wound has given way and coils of intestine have prolapsed through the abdominal wall (*Fig* 212) This is the common variety The patient often volunteers the information that he felt something give way *Pain and shock* are often singularly absent. Less frequently the wound breaks open more quietly revealing a mass of reddish tissue beneath One hopes that this mass is the rectus muscle but it nearly always turns out to be a coil of small intestine covered with granulation tissue. In other words, the abdominal wall has *given way a few days previously* and the prolapsed coil has been covered only by the skin. Thus it comes about that if there is uncertainty as to the nature of the reddish tissue it is safer to ascertain this point in the operating theatre

Fig 212.—Burst abdomen. (*After A M Shipley.*)

First aid Treatment.—In order to encourage the patient to lie quietly and to aid abdominal relaxation, *a suitable dose of morphine is administered at once* The patient is exhorted not to cough, if he can possibly avoid it The wound and prolapsed viscera are covered with sterile towels or packs wrung out in normal saline solution. These in turn, are covered by abundant cotton wool, and the whole is kept in place by a firmly applied many tailed bandage. The patient must not be left for a moment. Should he desire to cough, the hands support the abdomen. The stomach is emptied with a gastric aspiration tube which is left in place *An antibiotic with a wide range of activity e.g* aureomycin, is injected intravenously

Provided the patient is fit to undergo operation, arrangements are made forthwith. Even if the risk of operating is considered too great, unless the patient s condition is desperate he should be taken to the operating theatre for the non-operative treatment of burst abdomen (see p. 171).

RESUTURE OF THE ABDOMINAL WALL

When the patient s condition did not give rise to anxiety up to the time of the disruption, when shock is absent or responds readily to treatment, and when gross suppuration of the wound did not precede the bursting asunder of the wound, resuture is recommended.

Anæsthesia.—*If as is often the case the patient has a severe cough,* inhalation anæsthesia should be avoided, for the operation can be conducted under intravenous thiopentone and one of the curare-like drugs to ensure maximum relaxation. One per cent procaine infiltrated thoroughly into the subcutaneous tissues and the musculature along each lateral aspect of the abdomen 2–3 in. (5–7 5 cm.) from the wound produces a degree of anæsthesia and relaxation that permits resuture in spare subjects. To supplement local anæsthesia with a little thiopentone is a safe and efficient means of being enabled to carry out the operation fairly expeditiously

Operation.—Prolapsed intestine and omentum are again washed with saline solution, and the skin of the abdominal wall is cleansed with ether followed by alcohol. Blunt hooks placed beneath the extremities of the wound and a steady pull, *mainly in an upward* direction, are of great service If the patient is conscious the assistant must be careful to avoid jerking these retractors. If the patient is relaxed and the intestine is not greatly distended, the viscera slide into the peritoneal cavity with trivial assistance The greater omentum is spread out over them. It should be noted that if under half of the wound is disrupted one blunt hook *only* is used, and it is placed *in the extremity* nearest the

dehiscence In these circumstances only the disrupted portion of the wound is repaired When, as is more usually the case more than half the wound is involved, the dehiscence is completed with the finger and if necessary scissors to cut the sutures It is easier (and safer) to suture the whole of the incision afresh

In order to protect the intestines and keep them in place an abdominal pack is inserted, and on this is laid a Sargent's depressor (*see Fig* 5, p. 2) or if a McNealy's rubber guard (*see Fig* 6 p 2) is to hand it can be used instead of the pack and the Sargent's depressor may then be unnecessary The edges of the wound will be seen to be œdematous and the peritoneum and posterior rectus sheath glued together and retracted beneath the rectus muscles. Obvious pieces of catgut and other suture materials are removed from the wound.

It is useless to attempt to resuture the abdominal wall in layers. The œdematous retracted edges of the peritoneum are difficult to define and will probably cut out when an attempt is made to approximate them.

Either of the following methods of resuturing the abdominal wall will be found to be satisfactory they do not differ in principle—only in the matter of suture material.

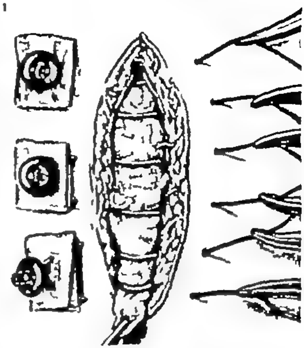


Fig 213.—Very stout mattress silk sutures are passed through all layers. The illustration shows trouser buttons with petroleum-jelly gauze beneath to prevent cutting in. If these are not available, pieces of ⅛ in. (3·2 mm.) diameter rubber tubing threaded on the mattress can be substituted.

Great reliance can be placed in through-and through mattress sutures, but the suture material must be *really strong heavy silk or stainless steel wire about 28 (or larger) gauge* *Although stainless steel is somewhat difficult to pass, its advantage over silk is that it does not harbour infection.* Silk has been tested in the crucible of experience and unless one is accustomed to suturing with wire this grave emergency is not the time to commence to do so

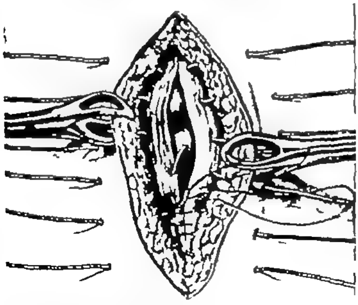


Fig 214.—Method of closing the aponeurotic layer The skin is dissected back on either side and the needle is passed parallel to the wound edge as shown.

Resuture using Thick Silk.—Employing a large curved cutting needle the thick silk sutures traverse the abdominal wall quite an inch (2·5 cm) from the edges of the wound (*Fig* 213). Some device to prevent the mattress sutures cutting into the skin must be employed. The best is trouser buttons with petroleum-jelly gauze beneath, but fairly stout pieces of rubber tubing suitably threaded on the mattress can be substituted. When tying these through-and through sutures it is essential to be certain that a coil of intestine has not been entrapped beneath one of them also that the abdominal pack, which remains until the last of them is to be tied, has not become entangled. As emphasized already these mattress sutures are the mainstay and are probably quite adequate to ensure

the integrity of the secondary closure. There is, however, a feeling of security in reinforcing them. The skin is reflected from the abdominal wall for a short distance on either side, care being taken not to cut the through-and-through sutures. Using interrupted stitches, preferably of very stout catgut, the needle is inserted parallel to the wound edge (*Fig.* 214). A grip of healthy tissue is thus obtained. Sufficient gaps between these stitches must be left to permit drainage. No intraperitoneal drainage is employed. The skin is approximated loosely. Corrugated rubber drainage of the subcutaneous tissue is advisable.

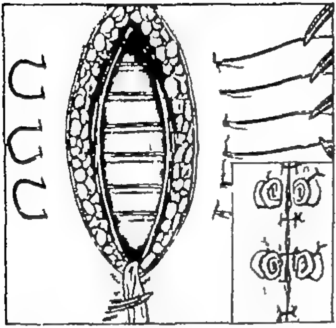
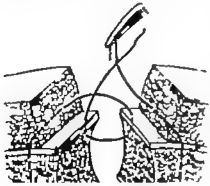


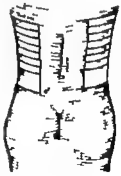
Fig. 215.—Stainless steel sutures passed through all layers of the abdominal wall. McNealy's rubber guard in use. (*Modified from Farquharson.*)

Resuture with Stainless Steel Wire.—The passage of this stout wire is made much easier if the wire is attached to the needle in the manner shown in *Fig.* 207, p. 164. The precautions regarding avoiding kinks in the wire as described on p. 165 must be taken. The mattress sutures are passed through the abdominal wall in exactly the same manner as detailed for silk sutures. After all have been inserted (*Fig.* 215) they can, with advantage, be tied over swabs (*Fig.* 215, *inset*). Taking the precautions described already to ensure that each and all the sutures do not entrap a coil of intestine or the abdominal pack, the ends of the wire, to which hæmostats are attached, are tied by twisting; the first twist is the all-important one, for upon it depends the amount of tightening of the wire, which must be just sufficient to bring the cut surfaces of the abdominal wall into close apposition. Six to eight twists being accomplished, the ends are clipped fairly short, and their sharp extremities are twisted over towards the skin.

After resuture of the abdominal wall has been completed by either of the two methods described, the wound is painted with an antiseptic, and a large number of layers of gauze is applied. The dressings are retained by a many tailed bandage over wool.



The Smead Stitch for resuturing the Abdominal Wall.—When the general condition of the patient is good, abdominal distension is not great, and the anæsthetic provides perfect relaxation, the Smead stitch (*Fig.* 216) to approximate the peritoneum and the muscular layers can be used with The wound



scars that are inseparable from the use of through-and through stitches. In strength the Smead stitch compares favourably with the through-and through variety

Dressing the Wound.—Whatever method of suture is employed after dressings have been applied the wound should be strapped by the imbrication of straps of adhesive plaster encircling two-thirds of the circumference of the trunk (*Fig* 217) If it is to hand, an equally effective method is to apply a ready made abdominal corset (*see Fig* 221 p. 173)

NON-OPERATIVE TREATMENT OF BURST ABDOMEN

The advantages of well-conducted non-operative treatment should receive careful consideration. For a patient in poor condition there should be no option. It is also advised when the patient has a severe cough or other pulmonary complication. Another indication is a grossly infected wound before the disruption.

The method does not preclude the possibility of resuture of the abdominal wall when the patient's condition improves sufficiently; on the other hand the method *per se* is often surprisingly successful although, of course the incidence of post operative ventral hernia is high

Technique—When possible it is preferable to undertake the treatment in an operating theatre If it is necessary for the measures about to be described to be carried out with the patient in his bed it is of fundamental importance for the surgeon and his assistant to be masked, gowned and gloved.

Fig 218.—The surgeon, exhorting the patient to relax, applies even pressure on the gauze-covered coils to reduce them into the abdomen as far as possible The assistant makes certain that the plaster on the left has adhered firmly

Only after the sedative has taken effect are the first-aid dressings removed It is best to confine skin preparation to ether (which removes grease and therefore favours the adhesion of adhesive plaster) and alcohol. Even these relatively bland substances should be kept from coming into contact with the vulnerable serosa of the intestines. When coils of intestine are obviously soiled, they should be cleansed with dripping wet saline soaked swabs. Pieces of gauze wrung out in saline solution, so that they are merely damp are prepared, each being of such a size as to cover and overlap the protruding viscera. After the coils have been gathered into the centre of the wound, a layer of gauze is applied and the surgeon reduces the prolapsed viscera as far as possible and holds them with cupped hands, while the assistant tucks the edges of the gauze under the lips of the wound Three to five such layers are applied. Strips of adhesive plaster (not flexible adhesive plaster) are cut. In the case of a disruption of a vertical incision they should be long enough to extend across the abdomen from one posterior axillary line to the other The skin is dried by the assistant who removes her gloves, and applies a strip of adhesive plaster to the left side of the abdominal wall (*Fig* 218) In order to make sure that it has adhered, she keeps it pressed on to the skin while the surgeon takes the free end of the plaster and, rendering the strip taut, draws it across the gauze-covered protrusion (*Fig* 219). The surgeon likewise takes precautions to ensure firm adhesion to the skin, and at the same time makes sure that the strip is really tight. Both surgeon and assistant keep up the pressure

Fig. 219.—The assistant, still ensuring that the plaster on the left adheres, places her right hand on the abdomen before the surgeon removes his left hand to take charge of the free end of the plaster

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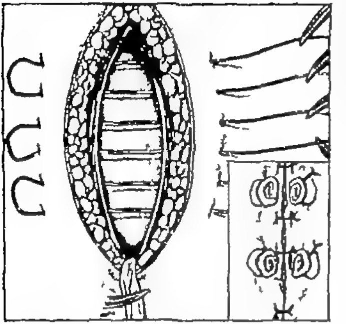

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Fig 216.—The Smead stitch.

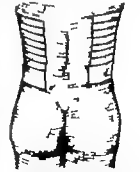

Fig. 217.—Showing how straps of securing adhesive plaster should be applied (posterior view).

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[1] Meyerheimer and Winfield advise No 00 cable wire for this purpose It is easier to tie than stainless steel wire and equals the latter in its non-irritating qualities.

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Fig. 219.—The assistant, still ensuring that the plaster on the left adheres, places her right hand on the abdomen before the surgeon removes his left hand to take charge of the free end of the plaster

until the plaster has stuck. The centre of the wound is treated first. Overlapping strips are applied above and below with the same care until the whole wound is covered. Each day observing the same aseptic precautions, the adhesive plaster is re-applied. This is necessary for within 24 hours the adhesive strips become slack mainly because (if they have been applied properly) the evisceration is less. To prevent greater protrusion, should the patient cough or strain, the adhesive strips are removed and replaced one at a time. During this process it is desirable to change some of the outer pieces of gauze which are saturated with sanguineous secretion.

In certain instances, infiltration of procaine into the abdominal wall is helpful in effecting relaxation. It should be noted particularly that *the gauze square lying in immediate contact with the intestines should not be removed for four or even five days*. By this time it will be found that it is loose and can be peeled off without difficulty. When this has been done it should be possible to coapt the wound edges, especially if a good result to an enema was obtained half an hour previously.

AFTER TREATMENT (All Cases)

Paralytic ileus is of such frequent occurrence that transnasal gastro-intestinal aspiration is advisable for some days in all patients whose intestines have prolapsed. Full supportive treatment includes fluids intravenously, blood transfusion, oxygen if required, antibiotic therapy, a high-protein intake and vitamins. When resuture has been undertaken the through-and through stitches should remain in place for 14–18 days, and then every other one removed. From thence forward, until sound healing has occurred, the wound must be supported by corsettage.

The remote after-care will include regular examination for the development of a ventral hernia.

THE PREVENTION OF BURST ABDOMEN

Unless the surgeon and those who care for the patient during the post-operative period strive to keep the possibility of wound disruption in mind, the incidence of a burst abdomen will continue to remain at least 1 in every 200 laparotomies, and if emergency laparotomies are alone considered, this incidence will be doubled. What happens is that after a case has occurred, suitable precautions are taken for a time but the memory of the case soon fades, and it requires another case to focus the team's attention on the simple but all important, measures detailed below—precautions that, if taken in time, will reduce the incidence of this complication very considerably.

(*a*) *The Surgeon.*—The most essential single aspect in the prevention of wound disruption is the intimate approximation of the edges of the peritoneum so as to prevent the entrance of an omental wedge (W. I. Wolff). At the close of the operation in any patient who had a pre-operative cough, is (or is likely to become) distended, or is suffering from malnutrition, the surgeon will do well to apply corsettage to the abdomen instead of the more usual form of dressing.

(*b*) *The Anæsthetist* should avoid removing an endotracheal tube while the cough reflex is present. The provision of a Hewitt's airway while the patient is coming round from the anæsthetic will do much to prevent undue straining while the patient is regaining consciousness.

(*c*) *The House Surgeon*, on the surgeon's instruction, should as a routine ensure that the patient is receiving an appropriate intake of vitamin C and proteins. He should know that early ambulation, by preventing atelectasis, has probably lowered the incidence of this complication. If the patient has a hacking [illegible] house surgeon [illegible] sult
a medical colleague how best to keep the cough in sub[illegible]
From the time he commences his duties, he shoul[illegible] the signific[illegible] ro-
sanguineous discharge from a wound, and report it [illegible]

(*d*) *The Nursing Staff* should apply suitable [illegible] ts, wit[illegible] By
being asked to do so. This is such an excellent [illegible] ing al[illegible] nds
that it should be applied as a routine after all [illegible] and
wound of any patient [illegible] elops a cough, be [illegible] or
malnutrition.

Laparotomy cors[illegible] of sheet adhes[illegible] eat n
a corset is that devised [illegible] Kelly. A p[illegible] folde

not quite in the midline its sticky side out Nicks are made with scissors in the fold (*Fig* 220 A) just large enough to allow a dressmaker s hook but not its flattened arch

Fig 220.—Kelly s method of fixing hooks to adhesive strapping

to be pulled through When enough hooks have been inserted a second piece of strapping is placed over the first sticky side down (*Fig* 220 B). The strapping is fixed to the skin

Fig 221 —An abdominal corset in use

A B

Fig. 222.—A, The reinforced edge of the corset is cut with strong scissors. B, When thus sectioned, the corset can be moulded to the shape of any abdomen.

parallel with and about one and a half inches (3 8 cm.) from the edges of the wound. The hooks are then laced with a length of stout silk.

An exceedingly good form of laparotomy corset is one ready made for use—it is usually required in a hurry The ready made corset[1] (*Fig* 221) answers admirably and

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[1] Made by Charles Thackray Ltd., Leeds.

may well be at hand, for sooner or later it is sure to be needed. It is a good practice to section the corsets, as shown in *Fig.* 222 A and B. They are then less rigid and fit to the contour of the abdomen.

Mortality following burst abdomen varies very considerably in different reported series. It is as low as 11 per cent, and as high as 40 per cent. A mean may be taken from recent statistics of the Mayo Clinic, where the mortality is 18.1 per cent. What must be taken into consideration is that in all hospitals a certain number of the patients die after disruption of the wound not on account of the disruption but from their disease, e.g., advanced malignant neoplasms.

G. B. McAdams gives the necropsy findings in 10 cases of burst abdomen, which disclosed diffuse peritonitis in 6, a fistula of the small intestine in 2, atelectasis in 1, and what appeared to be death from post-operative shock in the remaining case. Lowering of the mortality can only come about by very skilful choosing of those cases that should be treated by immediate resuture, those that should be treated by delayed resuture, and those in whom non-operative treatment should be employed.

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CHAPTER XLII

THE ABDOMINAL WALL AND THE EXTRAPERITONEAL TISSUE SPACE

The importance of some of the conditions described under this heading lies in the fact that they mimic an intraperitoneal lesion. Many of them call for the surgeon's diagnostic acumen rather than his operative skill but they should not be relegated to a back seat on that account.

HÆMATOMA OF THE RECTUS MUSCLE (TEARING OF THE INFERIOR EPIGASTRIC ARTERY)

This clinical entity occurs in three dissimilar types of individual viz. elderly women often thin and feeble athletic muscular men, usually below middle age and pregnant women, mainly in multipara and late in pregnancy

The site of the hæmatoma is most often below the level of the linea semilunaris where the posterior sheath of the rectus abdominis is lacking (*Fig* 228) but it is not always in this situation.

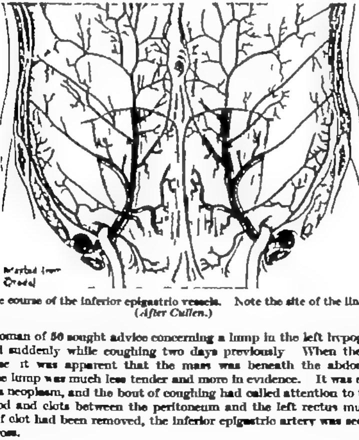

Fig. 221.—The course of the inferior epigastric vessels. Note the site of the linea semilunaris. (*After Cullen.*)

A thin, pale woman of 50 sought advice concerning a lump in the left hypogastrium which, she said, had appeared suddenly while coughing two days previously When the recti abdominales were rendered tense it was apparent that the mass was beneath the abdominal musculature. Three days later the lump was much less tender and more in evidence. It was considered probable that the mass was a neoplasm, and the bout of coughing had called attention to the lump. Laparotomy revealed blood and clots between the peritoneum and the left rectus muscle After a considerable amount of clot had been removed, the inferior epigastric artery was seen spurting—it had been torn right across.

In most cases it is the tearing asunder of the artery and possibly the vein that is the causative lesion, and rupture of the adjacent muscle-fibres plays an insignificant part.

Unless there is bruising or ecchymosis of the overlying skin, which is unusual in early cases, the diagnosis is difficult One should always consider the possibility of hæmatoma of a rectus abdominis if an exquisitely tender lump appears in relation to this muscle after a bout of coughing The conditions with which the hæmatoma is frequently confused are

in the female a twisted ovarian cyst, and in both sexes, when the lump is on the right side an appendix abscess. The sign most likely to be of value in differentiating a hæmatoma of the abdominal wall from these conditions, namely tensing the abdominal musculature, is often inapplicable because of the intense pain it causes.

A navvy was admitted with a tender lump in the right iliac fossa. He stated that he had experienced sudden pain in the right side while striking with a heavy hammer eight hours previously. I paid little heed to the history of an accident, and thought the tender mass was probably an appendix abscess. At operation a surprisingly large quantity of blood and blood-clot was found between the deep surface of the rectus muscle and the fascia transversalis.

Again, the differential diagnosis between a strangulated Spigelian hernia (see p. 433) and a hæmatoma of the rectus abdominis is sometimes impossible. The absence of vomiting favours the latter, while a plain radiograph of the abdomen sometimes gives positive evidence of the former.

Fig 224.—In this case of spontaneous rupture of the inferior epigastric artery after the rectus sheath was incised blood-clot immediately extruded itself. (*W. F. Walker.*)

Hæmatoma of the rectus abdominis with tearing of the inferior epigastric artery is a supremely important diagnosis during pregnancy. If operation is performed, the fœtal mortality is 25 per cent (Sheehan). On the other hand, in the rare event of the diagnosis being certain, small as it is, one must take into consideration the danger to the life of the mother. Surprising to relate, the hæmorrhage into this closed space from a comparatively small artery can prove fatal. Hobbs's patient, a pregnant woman, died one hour after admission to hospital from the severity of the bleeding. At necropsy 3 pints (1·4° L) of blood were found in the abdominal wall beneath the left rectus muscle.

Treatment.—In the majority of cases of hæmatoma of the rectus abdominis muscle because of the concomitant tearing of the deep epigastric vessels, it is safer to operate. It is true that, with rest, resolution of a comparatively small hæmatoma is probable, but occasionally under expectant treatment renewed hæmorrhage has caused the hæmatoma to rupture into the peritoneal cavity. For this reason, as well as for uncertainty in diagnosis, expectant treatment should be reserved for those cases where the lump is small and ecchymoses in the overlying skin make the diagnosis certain. *Operation consists in* evacuating blood (*Fig.* 224) and clot and ligating bleeding vessels, if such can be identified. It is usually futile to attempt to repair the muscle—the stitches merely cut out. When hæmostasis is perfect the wound can be closed without drainage, but, if there is oozing, a corrugated rubber drain should not be omitted.

SPONTANEOUS THROMBOSIS OF A SUPERFICIAL EPIGASTRIC VEIN

This is a condition that is seldom described in the literature. Thrombosis of a superficial epigastric vein gives rise to pain in one or other iliac fossa; when situated on the right side, the symptoms are liable to be mistaken for those of appendicitis. On examination, beneath the skin there is an elongated, firm, pencil-like elevation which, in the early stages, is extremely tender (*Fig.* 225). Patients observed with this condition have been spare men; it is probable that the thrombosed vein is obscured when the abdominal wall is well covered with fat. Like other cases of thrombosis, the condition resolves and all that is required is one week's rest in bed.

Fig. 225.—Facsimile of the diagram accompanying the notes of a case of spontaneous thrombosis of the right superficial epigastric vein.

POST OPERATIVE CELLULITIS OF THE ABDOMINAL WALL

Pseudo-cellulitis (Post-operative Air Entrapment).—In case the reader is unfamiliar with the phenomenon of air entrapment in the subcutis after laparotomy a brief description of this innocuous condition will be given.

Around the incision—indeed sometimes a considerable distance from it—unmistakable crepitation can be elicited. Although there are no general signs, those who have not seen or heard of the condition on finding this crepitation fear that gas gangrene is developing. Left alone this curious surgical emphysema disappears in the course of a few days.

True Cellulitis can occur in any of the planes of the abdominal wall. Always a serious condition, the deeper the cellulitis the more it is to be feared—the zenith in this respect being cellulitis of the retroperitoneal tissues. (See p. 186.)

It should be noted that in superficial cellulitis of the abdominal wall crepitation is often detected; this is much more frequently due to *Esch. coli* than to the organisms of gas gangrene.

Superficial Cellulitis.—Because of pyrexia the abdominal wound is inspected. That superficial cellulitis has developed cannot be mistaken. The earliest sign is that the stitches became embedded in the oedematous skin. Later there is a blush extending over a variable distance from the incision or the stitch holes. One should assemble the necessary materials to obtain a specimen of purulent fluid for bacteriological examination together with a fine scalpel and a haemostat for removal of a stitch, and a probe. The instruments are sterilized, and having scrubbed up and donned gloves the wound is gently but systematically palpated for an area more indurated and tender than the remainder. This is a most important examination. If such an area is found, the stitch in the immediate vicinity is removed. It is usually necessary to separate the skin edges over a tiny area. If even one drop of serum or sero-pus escapes, one is rewarded by being given the opportunity to determine the infecting organism and its sensitivity to antibiotics.

Since a mixed infection is the rule while awaiting the report, an antibiotic with a really wide antibacterial range is required and the choice falls on one of the tetracyclines.

Laparotomy corsets should be applied. The wound is covered with a dry dressing; fomentations are not recommended. If no exudate is obtained, the examination must be repeated on the following day, but no further stitches are removed unless there are definite indications for so doing. Probing the deeper planes of the incision is sometimes rewarded by a gush of pus.

Cellulitis complicating a Faecal Fistula seldom spreads for more than 1 in. (2.5 cm.) around the incision. The differential diagnosis between excoriation of the skin (see p. 520) and this condition must be made. Especially in artificial light, it is sometimes difficult to be sure which of these two conditions is present, but if induration can be felt, it is certainly cellulitis.

Spreading Cellulitis.—In spreading cellulitis the oedema and redness continue to extend from the edges of the wound towards the flanks.

Spreading cellulitis seems to occur under stereotyped, although divergent, circumstances, of which the following may be taken as leading examples.

Type A. After Operation for Strangulated Umbilical Hernia.—This is the most preventable type. If proper attention is given to the preparation of the skin (see Chapter XIV) and the subcutis is drained even without antibiotic therapy the condition is unlikely to occur.

Type B. Commencing in a Stab Wound made Well Posteriorly in Cases of Retrocaecal Appendicitis.—Of necessity such stabs traverse vulnerable retroperitoneal tissues and a considerable thickness of fleshy muscle. In cases of frank appendix abscess a stab incision in this position is not necessary. In other cases (e.g. gangrenous retrocaecal appendicitis), fearing this complication, it is better to insert a soft drain, e.g. a Penrose wick drain, via a gridiron incision or, if a paramedian incision has been employed, through a counter incision in the anterolateral abdominal wall.

Type C. As a Complication of Intestinal Leakage e.g. after resection and anastomosis, especially of the large intestine.

The management of spreading cellulitis is similar to that described above, but should these measures prove inadequate it is advisable to make an incision into the inflamed area on one or both sides, rather than to open up the laparotomy incision and risk a burst abdomen; however, incision is best avoided until undoubted softening occurs in some part

of the indurated area. The exception to this rule is in spreading cellulitis following partial colectomy where, in addition to providing free drainage down to the site of the anastomosis, it may be advisable to perform urgent proximal colostomy

Deep Cellulitis is more difficult to diagnose. Often the incision appears to be healing well. The leading signs are brawny œdema towards one or both flanks. Not infrequently there is œdema of the scrotum or vulva as well. These signs usually develop about the fifth day after operation, i.e. later than superficial cellulitis. Antibiotic therapy is the mainstay of treatment. Tenderness is variable, but when it persists it is a signal that an incision is required. The incision is made in the area of greatest tenderness. The muscle layers are incised cautiously until pus or purulent fluid is encountered. Drainage is most necessary

Gas Gangrene of the Abdominal Wall is surprisingly rare. The presence of malodorous pus containing gas is more likely to be due to a commencing fæcal fistula than to gas gangrene. When, however the skin takes on a bronze tinge that is so characteristic of gas gangrene and the wound discharges dark, blood-stained fluid with a mousy odour and crepitation can be elicited, no time should be lost in opening the wound and excising its gangrenous margins. Next, non-contractile non-bleeding and therefore non-viable muscle must be sacrificed ruthlessly with the knowledge that a large ventral hernia is inevitable. It is usually necessary to saucerise the wound, leaving only the diaphanous peritoneum at its base. Into this excavation hydrogen peroxide is instilled, after which the wound is irrigated with saline solution in order to remove debris. The wound is filled with gauze moistened with hydrogen peroxide. Into the muscles at the periphery is injected, at intervals, 100,000 units of polyvalent anti-gas-gangrene serum. The systemic treatment of gas gangrene with antibiotics and anti-gas-gangrene serum is described on p. 122.

PROGRESSIVE POST-OPERATIVE SUBCUTANEOUS GANGRENE

This distressing clinical entity (also known as Meleney's ulceration because it was Dr F Meleney of New York, who brought the condition to notice) is fortunately rare. Most of the reported cases have followed abdominal operations for a perforated viscus,

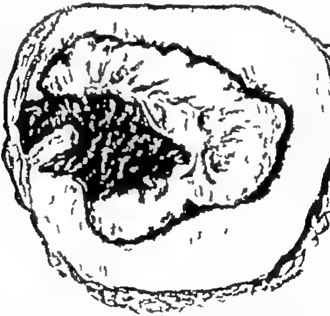

Fig 226—Portion of the abdominal wall excised in a case of progressive post-operative subcutaneous gangrene following an operation for perforated duodenal ulcer (*H T Car*)

notably that occurring in connexion with acute appendicitis, but the superficial tissues around empyema and suprapubic wounds are not exempt. There is severe pain in the wound, but only somewhat late in the course of the complication are constitutional symptoms much in evidence they then take the form of (comparatively) apyrexial increasing toxæmia. This curious superficial gangrene (*Fig* 226) progresses slowly but relentlessly

Meleney has shown that the condition is due to symbiotic infection of a non haemolytic streptococcus and (usually) the *Staph aureus haemolyticus.*

Treatment.—Excision of the involved area formerly the standard method of treatment, is now unnecessary To start with systemic penicillin and streptomycin are employed but if the sensitivity tests of the causative organisms so indicate these antibiotics are changed The report by Meleney of 5 cases treated with bacitracin in 4 of which penicillin had proved ineffective indicates that the administration of bacitracin is the treatment of choice.

The best local application is zinc peroxide paste It is essential for the zinc peroxide powder to be sterilized in an oven at 140 C for four hours before use. Zinc peroxide powder and sterile water (equal parts) make a smooth cream.

The paste is applied directly to the wound and covered with two layers of gauze impregnated with the paste this, in turn is covered by petroleum-jelly gauze. The dressings are changed daily This treatment is continued for fourteen days, by which time the area should present a clean, healthy granulating surface to which skin grafts can be applied.

In all the infections of the abdominal wall described above general treatment is most necessary for it is probable that the patient s defensive mechanism is defective. Anæmia must be corrected with iron or small blood transfusions, and a high-protein diet with ample vitamin intake is advisable

OMPHALITIS

When the umbilical cord becomes infected, with antibiotic therapy (penicillin and streptomycin unless sensitivity tests dictate otherwise) the inflammation often remains strictly localized. By employing warm, moist gauze dressings, the crusts separate giving exit to purulent exudate Exuberant granulation tissue frequently forms, and requires the application of silver nitrate After the granulations have been destroyed epithelialization occurs rapidly

Infection of the umbilicus is liable to spread along the defunct hypogastric arteries and umbilical vein (*Fig* 227) The fact that these vessels are separated from the abdominal cavity by only a single layer of peritoneum and a little areolar tissue makes the vulnerability of the peritoneal cavity to invading umbilical infections at once apparent. Necropsy studies have shown that the lumina of these vessels may contain only partially organized clot up to 50 days after birth Consequently infection of the peritoneum via the umbilicus is possible until the age of six weeks.

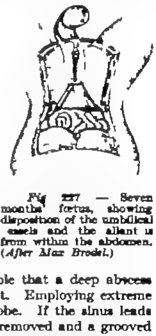

Fig 227 — Seven months' fœtus, showing disposition of the umbilical vessels and the allant is from within the abdomen. (*After Max Brodel.*)

In any given case, one or more of the following complications may supervene —

1. **Cellulitis of the Abdominal Wall** is often the precursor of —

2. **Abscess of the Abdominal Wall,** which occurs particularly along a hypogastric artery or less frequently in association with the falciform ligament (umbilical vein)

If gentle pressure exerted below or above the navel causes a bead of pus to exude from the umbilicus, it is extremely probable that a deep abscess associated with one of the defunct umbilical blood vessels is present. Employing extreme delicacy the tiny umbilical opening is investigated with a fine probe. If the sinus leads downwards along the course of a hypogastric artery the probe is removed and a grooved director is passed down the tract. The full thickness of the abdominal wall is divided with a scalpel, keeping strictly to the groove of the director Only in this way can opening the peritoneum be avoided with assurance. It may be possible to open an abscess above the umbilicus by the same technique, but usually it has to be drained by a direct incision in the middle line.

3. **Extensive Ulceration of the Abdominal Wall** is treated in the same way as progressive post-operative subcutaneous gangrene (*see above*)

4. **Septicæmia** can occur by infection entering the blood-stream via the umbilical vein. In addition to the usual signs of a blood-stream infection jaundice is liable to occur If abscesses (e.g., dactylitis) develop they must be drained in particular an abscess above the umbilicus should be sought.

5. **Peritonitis** carries a bad prognosis. If an abscess of the abdominal wall is present it should be drained it is failure to drain such an abscess early enough that is often the

cause of the peritonitis. In the first place the treatment of the peritonitis is conservative. When an appreciable amount of peritoneal fluid is present, the insertion of an intraperitoneal suprapubic drainage tube should not be delayed. In both septicæmia and peritonitis blood transfusion is indicated

SUPPURATING DEEP ILIAC LYMPH NODES

Acute inflammation of the deep iliac lymph nodes forms a clinical entity that has not received the attention it deserves. It is far from rare and often gives rise to serious symptoms. Acute appendicitis (when the right side is involved), acute purulent arthritis of the hip-joint, and acute osteomyelitis of the upper end of the femur are the conditions

Fig. 228.—Incision for draining suppurating deep iliac lymph-nodes, and method of opening an abscess connected therewith.

which are particularly likely to resemble it. To fail to recognize the condition, or confound it with those diseases that it mimics, is likely to prove a serious matter. Psoas spasm is a leading feature, particularly in the early stages of the disease. Curiously, the superficial lymph nodes are quite often uninvolved, which adds to the difficulty in diagnosis. In about three-quarters of cases a focus of infection in the shape of a scratch or a sore can be found in the relevant areas drained by the deep lymph-nodes.

Once a confident diagnosis has been made there is no occasion to operate for at least a few days. With antibiotic therapy over 30 per cent of cases resolve slowly (2 to 3 weeks). In cases where the swelling is not getting smaller or there are other reasons to suspect an abscess has formed, operation should not be delayed. The incision should be made on the medial side of the anterior superior iliac spine (*Fig. 228*), care being taken that the peritoneum is not opened. If by error (usually in diagnosis) the peritoneum is opened and the abscess is found to be extraperitoneal and unconnected with the appendix, the peritoneum should be closed and the abscess drained through a lateral stab incision.

Case 1.—A fish-frier aged 30 suddenly felt pain in the right groin which later spread over the whole abdomen. He vomited twice and went to bed. Thirty-six hours later he was sent to hospital and diagnosed as acute appendicitis. On examination the right thigh was slightly flexed but could be extended voluntarily. The superficial inguinal lymph-nodes on the right side were found enlarged and tender. A tender lump was found above the inguinal ligament. On examining the leg an infected blister was found on the heel. Three days later an extraperitoneal abscess was drained.

Case 2.—A boy aged ~ was admitted a ? osteomyelitis of the head of the femur ? left-sided appendicitis. He was gravely ill. The left thigh was flexed 90 and the spine was arched from the bed. There was an indurated painful swelling just above the inguinal ligament. The superficial inguinal lymph-nodes were not enlarged. Over the shin there was a healing sore. Eight days later pus was evacuated by an incision below and internal to the anterior superior iliac spine.

Case 3.—A youth, aged 1~ whilst coming out of a picture palace experienced acute pain in the right groin. He went home to bed. Two days later he got up and went to work. After half an hour he had to return home. Soon afterwards he vomited five times. On the sixth day he was admitted to hospital. His right hip was flexed and he looked very ill. He had passed no urine for twelve hours, and the bladder was distended. A catheter withdrew normal urine (reflex retention). Tenderness was marked just above the inguinal ligament. The superficial inguinal lymph-nodes on the right side were enlarged and tender. A primary lesion could be discovered on the limb. Three weeks later the symptoms had abated entirely. A complete urinary investigation was negative. Appendicectomy was performed and the organ was found to be normal.

Case 4.—A boy aged 7 had pain in the abdomen for a week. On examination the right hip was flexed. Extreme tenderness and some rigidity were present in the right iliac fossa. As there was no sign of a testis on the right side a diagnosis of ? torsion of an abdominal testis was made. Under the anaesthetic a lump was felt in the right iliac fossa. The peritoneum was opened through a gridiron incision. The appendix was normal and accessible so it was removed. The lump was found to be extraperitoneal. After closing the peritoneum the fascia transversalis was stripped laterally off the internal oblique until the abscess wall was reached. The abscess was then drained through a stab incision and the original wound closed. A thorough examination of the limb did not reveal a primary focus.

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CHAPTER XIII

DRAINAGE OF THE PERITONEAL CAVITY, THE RETRO-PERITONEAL SPACES, AND THE ABDOMINAL WALL

A cynic has remarked: "Books are no good, for what book tells you when to put in a drainage tube?" While recognizing that there is an element of truth in this remark, an earnest endeavour will be made in this chapter and in the appropriate sections of the chapters that follow to set out when, when not, and how to drain the multitudinous wounds, incisions, anatomical spaces, and pathological cavities that the emergency surgeon encounters or creates in the course of his work.

Many of these endeavours to expound the principles of drainage will fail, and fail miserably unless the operator explains to those who will be in attendance upon the patient why he inserted the drain and how he wishes it to be managed. The time to do this is before the patient leaves the operating theatre and the surgeon will find that usually it is safer to dictate written instructions. If this simple injunction is not heeded, sooner or later there is bound to be trouble. When the surgeon has not complete confidence, founded on personal knowledge, in those who are looking after the patient, he should attend to the drain himself or at least personally supervise its management.

Indications for Draining the Peritoneal Cavity.—The past thirty-five years have seen a great change in the matter of drainage of the peritoneal cavity. Nowadays tubes are not inserted in order to be on the safe side. Indeed Lawson Tait's maxim "When in doubt, drain" has been revised, and "When in doubt, don't drain" is the watchword. Tolerance in the matter of drainage has done much to enhance convalescence. *Fæcal fistulæ (often the result of pressure necrosis of a tube on the gut wall) are less common. Secondary hæmorrhage from pressure necrosis of the external iliac artery (due to the* obsolete practice of passing a tube via a lateral appendix incision into the pelvis) is an almost unheard-of tragedy. Post-operative hernia is less common. Above all, the danger of post-operative intestinal obstruction is minimized. Omitting unnecessary drainage and lessening the time drainage tubes are left in situ have undoubtedly played a part in improving results.

The great indications for drainage are: (1) The presence of a considerable quantity of free purulent material in the peritoneal sac; (2) When perfect hæmostasis is impossible; (3) The presence of an abscess; (4) When leakage of bile is anticipated or has, in fact, occurred.

"*Tell me, I beseech thee, wherein thy great strength lieth*"—*Judges* xvi. 6.
(Douai Version.)

Many surgeons seem to regard the peritoneum as being possessed of occult powers to resist and destroy pathological organisms—some unexplained property not vouchsafed to other tissues. On numerous occasions while dissecting a veil-like hernial sac, or mobilizing a sheet of peritoneum in the course of some abdominal operation I have reflected on this hypothesis, and have always come to the conclusion that it is unsatisfying. While admitting that the peritoneum can readily absorb fluid and even fine particulate matter, it is best to regard the *peritoneal exudate* as possessing the bactericidal properties that befriend the surgeon's efforts. Surely it is the very frailness of this metaphorical cobweb of endothelium that allows an unbridled migration of leucocytes and a swift and copious outpouring of serous fluid rich in natural antibodies, and, if they are in the circulation, antibiotics.

To drain or not to drain the peritoneal cavity; that is the question. Those who are opposed to drainage stated that animal experiments demonstrate that it is impossible to drain the whole peritoneal cavity for more than a few hours, which is certainly true. Furthermore, necropsies following tube drainage show that within forty-eight hours that part of a drainage tube within the peritoneal cavity becomes isolated by plastic adhesions. After that time the drainage tube, having become shut off from the general peritoneal cavity, continues to drain the sinus it has produced for itself, and to drain *that only*

Notwithstanding one must not lose sight of the fact that if a drain is properly placed it will provide a means for pus to escape instead of accumulating in the locality served by the drain

It is to be deplored that sometimes the desire to be up to date outweighs the canons of common sense and the dictates of reasoning Sir Alan Newton did not exaggerate when he lamented that "many appear to believe that it is tantamount to surgical incompetence to drain the abdomen He went on to show that at the Royal Melbourne Hospital the slavish following of the fashion of omitting drainage without really studying the problem led to residual abscesses and more serious complications. It is only too true that in spite of the fact that the pioneers of when in doubt don t drain were careful to stipulate that they wished to rationalize drainage (i.e not to have a rule of thumb not to drain without reason) many would be followers of the newer régime looked askance at those who continued to drain They lost sight of the fact that some exponents of drainage at the least provocation obtained first-class results, not I believe because of the unbridled drainage but because they had the services of trained ward Sisters, who personally carried out the after treatment taught them by the exponent. It is a truism that the *properly-managed* drainage tube can do little harm.

Weighty evidence of the value of drainage in cases of perforated appendicitis is furnished by Fowler and Bollinger In 128 cases of perforated appendicitis treated by appendicectomy *without drainage* but with full parenteral antibiotic therapy 19 developed an intraperitoneal abscess (usually in the pelvis) 6 an abscess of the abdominal wall, while 4 suffered from severe paralytic ileus. One patient sustained a burst abdomen. Most of these severe complications could have been prevented by appropriate drainage.

When to drain is, to a large measure founded upon the physical characteristics of this exudate (see p. 160). One must realize that milky fluid is not necessarily pus (the milkiness may be due to live leucocytes) that slightly red tinged, clear fluid may be a most lethal emulsion of streptococci that an astute surgeon uses his nose as well as his eyes, consequently "Is the exudate odourless or not?" is a consideration that assumes a position of cardinal importance. There are grades of odours, and different odours, that are impossible to describe. In conjunction with the physical characteristics of the exudate the pulse-rate must be taken into consideration. When the surgeon considers that the pulse-rate is elevated because of peritonitis he should be more ready to drain than not to drain.

In this work it is our aim neither to sew up completely without a reason nor to drain without a reason. Having elected to drain we (I include the reader) are not ashamed of our act on the contrary we noise it abroad and instil into our team the reasons for its employment. Last, but not least, we are resolved not to leave turning shortening, substitution for another and, above all the final removal of the tube —all incidents of prime, may vital, importance—to the vagaries of chance.

How Long should an Intraperitoneal Drainage Tube be left in?

An intraperitoneal suprapubic drainage tube while often a life-saving measure, becomes, if unattended, a menace. After forty-eight hours the tube must be turned and it should be shortened. It is only by attention to these points that a fæcal fistula and intestinal obstruction can be avoided. Picture a drainage tube passing into the rectovesical pouch coils of intestine must be in juxtaposition to the tube. If the tube is left undisturbed, pressure necrosis of an adjacent coil of intestine is almost bound to occur that such neglect favours intestinal obstruction is equally evident (*Fig* 229). After being in place for forty eight hours the retaining stitch should be cut, the tube turned, and a safety pin inserted through the tube. Usually on the third day the tube should be shortened considerably Unless there are reasons to the contrary it is a good practice to remove the tube[1] on the third day and substitute a piece of corrugated rubber but there is no fundamental objection to leaving a *short* tube through the abdominal wall.

There is seldom any difficulty encountered in placing a piece of corrugated rubber along the track left by a recently removed suprapubic drainage tube, particularly if the

[1] When a comparatively large intraperitoneal tube has been removed it is worth while remembering that a knuckle of small intestine may enter the aperture which persists for a short time in the abdominal wall. In the event of symptoms of intestinal obstruction arising suddenly soon after the removal of the tube, as a first step in their investigation a well-lubricated gloved finger passed into the track will enable prolapsed intestine to be felt, and reduced into the abdominal cavity To fill the track with petroleum-jelly gauze will prevent recurrence.

tube employed was a large one On the other hand, especially in other situations and in all when the diameter of the tube was less than half an inch, it requires skill greater than that to be expected of an average nurse to place the soft rubber material suitably In such cases a large rubber urethral catheter can be recommended It is passed along the

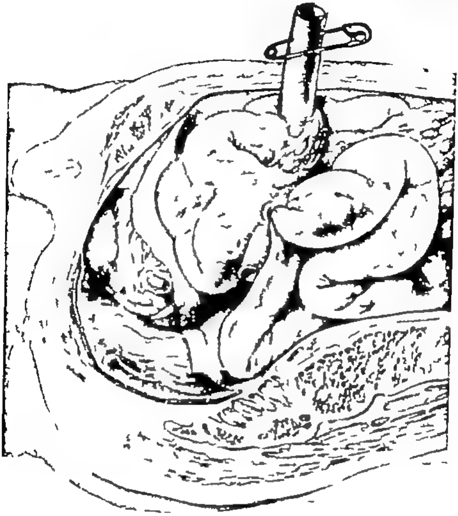


Fig 229 —The menace of an unattended drainage tube reaches its zenith in the greatest indication for its intelligent use. Note the coils of small intestine clinging to the tube and a portion of a coil becoming sucked into a lateral hole Who can wonder that intestinal obstruction is imminent?

track but only sufficient of the catheter to go through the abdominal wall is retained. A good-sized safety pin transfixes the catheter at the chosen point and the excess is cut off (*see Fig* 230). This is not wasteful the excess of the catheter can be put back into the drainage tube stock, while the portion in use can be boiled and used over and over again.

In the case of *a localized intraperitoneal abscess*, drainage should be continued until the exudate becomes serous. After ten days a sinus will become established, and by that time the tube can be removed entirely even if the exudate is still purulent.

Drainage of the Abdominal Wall and the Retroperitoneal Tissues.—When, after the removal of an infected focus or suture of a perforated viscus, it is deemed safe to close the peritoneal cavity the advisability of draining the abdominal wall requires lenient consideration. In this instance the watchword should be "When in doubt, provide some form of drainage" even if it be only a narrow strip of rubber glove in the subcutaneous tissues. Drainage of the superficial layers of the abdominal wall cannot possibly do any harm and in a rather high proportion of cases if such drainage is omitted, convalescence will be delayed

DRAINAGE MATERIALS AND METHODS OF ANCHORING THEM

Fig. 231.—The "bank roll" method of storing drainage tubes ready for sterilization.

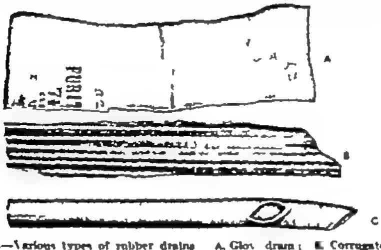


Fig. 232.—Various types of rubber drains A, Glove drain; B, Corrugated rubber drain; C, Rubber drainage tube

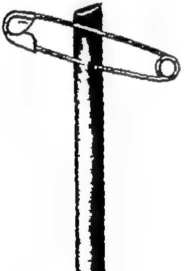


Fig. 230.—The end of a rubber catheter transfixed with a safety-pin is very suitable material for keeping open the track through the abdominal wall after a drainage tube has been removed.

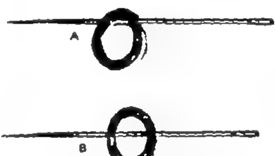


Fig. 234.—A, Correct method of passing a stitch through a drainage tube. B, Incorrect method—when the suture is tied the lumen of the tube will be almost obliterated.

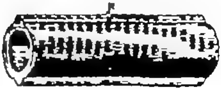


Fig. 233.—Greenwood's rubber drainage tube. The anchoring stitch passes through one of the ridges (R) and thus cannot constrict the lumen of the tube. Also leakage at the point of perforation by the stitch is obviated.

by wound infection. In cases where the retroperitoneal tissues are unquestionably infected, as is pointed out in several sections of this work, the freest possible drainage should be provided, and there should be no hurry to take out the drainage tube or tubes. They should, however, be turned after forty-eight hours.

In order to counteract the popular teaching that *all* drainage tubes should be removed after forty-eight hours, when dealing with a drainage tube in the perirenal tissues, an excellent dictum is: "It is better to leave a tube in the perinephric space a week too long than take it out a day too early."

MATERIALS FOR, AND METHODS OF, DRAINING THE PERITONEAL CAVITY

Rubber versus Plastic Tubing.—Polythene is less irritating to the tissues and, unlike rubber, does not become easily and deeply infected. Polythene tubing loses some of its pliability at each sterilization, becoming more rigid, whereas rubber can be boiled over and over again. Polythene is much more suitable for use in the Tropics, where rubber becomes useless in a very short time.

Drainage Tubes.—In every emergency operation these should be at hand. The 'bank roll' method (*Fig.* 231) of storing a selection of rubber drainage tubes is very

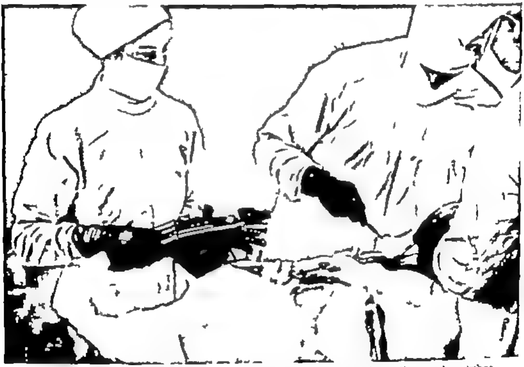


Fig. 232.—A suprapubic drainage tube about to be inserted. Note that various tubes are being offered, in order that the surgeon may make his own selection.

convenient. The roll is sterilized by boiling, and when a drainage tube is required the packet is unrolled and placed before the surgeon (*Fig.* 232), who selects a tube to his liking (*Fig.* 233).

Before use, the distal end of the tube is bevelled. Most surgeons cut one or more side holes, but considerable thought should be given to this step. It should be remembered that side holes render that part of the tube beyond a side hole ineffective, and that the ingress of fluid through a large side hole is likely to attract a portion of small intestine, which not only blocks the hole until the tube is turned, but is a probable cause of angulation that may lead to intestinal obstruction. Side holes should, therefore, be small.

Corrugated Rubber is a valuable form of drainage material. It can be cut so as to contain 2, 3, or 4 corrugations. Corrugated rubber is employed when it is desired to drain the deeper layers of the abdominal wall. Several references to it will be made in this work.

Glove Drain.—A piece of rubber glove about 1 in. (2.3 cm.) wide and 2 in. (5 cm.) long, rolled longitudinally into a scroll, is excellent when it is considered advisable to drain the

subcutaneous tissues only—for instance when hæmostasis of the abdominal wall is not perfect

All drainage tubes and other drainage material should be anchored to the skin by a stitch. In the case of a drainage tube the stitch should pass through one side of the tube and not through its centre (*Fig* 234): if a stitch traverses the middle of the tube when the stitch is tied the tube will be compressed. Greenwood's drainage tube (*Fig* 235) is an improvement on the simple circular tube. The stitch is passed through the ridge.

Insertion of a Suprapubic Drainage Tube —Suprapubic drainage, the best method of draining the pelvis and general peritoneal cavity, is required most often after the abdominal cavity has been opened already by another incision.[1] When this is the case

Fig 236.—Supplementary suprapubic drainage. Making the incision.

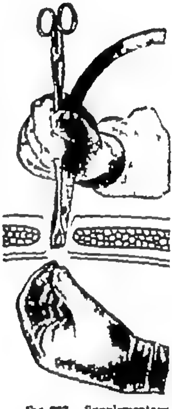


Fig 237.—Supplementary suprapubic drainage. Method of inserting the tube.

suprapubic drainage may be carried out as follows: through the original incision the left hand is introduced in the case of a laparotomy wound or the fingers of the left hand in the case of a gridiron incision and the middle line above the pubis is sought from within. The median plane is recognized easily by touch as a shallow trough between the two recti. By running the finger up and down in this groove it is ascertained that nothing intervenes between the peritoneum and the gloved finger. Having selected the point above the symphysis pubis, the index finger is passed to the left and the middle finger to the right of the midline. Exerting upward pressure with these two fingers, cut down between them (*Fig* 236). The cut extends to the peritoneum. If the latter is opened, so much the better. If not, the index finger pushes up the peritoneum, when it is picked up in a hæmostat and incised. The drainage tube held in a pair of forceps (*Fig* 237), is guided by the index finger and once within the peritoneum is grasped and conducted to the bottom of the rectovesical pouch. After it has been ascertained that the tube is lying correctly it is anchored to the skin by a stitch. Often another stitch is required to close the skin snugly but not tightly about the tube. The excess tubing is cut off. It is a mistake to cut it flush with the skin. It should project above the skin level about half an inch. Before the dressings are applied, it is an excellent practice to place a sterile safety pin through the tube to prevent it being lost within—a rare but embarrassing complication (*Fig* 238).

Alternative Method.—Some experienced operators find a thimble on the left index finger a useful instrument. A disadvantage is that the thimble robs one of the sense of touch, and as a consequence it is possible to wound a coil of intestine when cutting down upon the encased finger tip.

Fig. 238.—Radiograph showing a drainage tube which was lost in the peritoneal cavity. A safety-pin through a suprapubic drainage tube prevents this accident. The other tubes shown are a catheter in the rectum and a second catheter through the suprapubic incision.

Fig. 239.—Drainage of Rutherford Morison pouch. Making a stab incision in the flank.

Inserting a Tube into Rutherford Morison's Pouch.—Rutherford Morison's right kidney pouch will hold a pint of fluid without overflowing into the general peritoneal cavity or into the lesser sac. As a rule drainage of this pouch is required when the abdomen has been opened already. A stab wound is made in the flank towards the tip of the 11th rib (*Fig.* 239), coils of intestine being guarded carefully during the whole manœuvre. A long hæmostat is passed through the counter incision and its point made to emerge in the

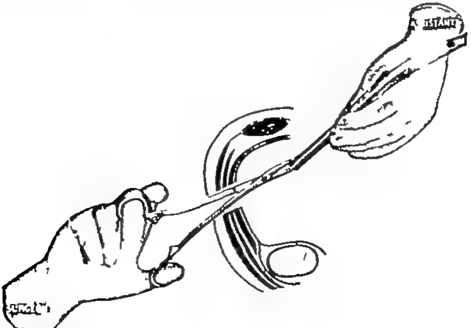


Fig. 240.—Drainage of Rutherford Morison pouch. Drawing the tube through the abdominal wall. It should be noted that the eye of the tube is towards the assistant.

laparotomy wound The jaws of the forceps having been opened widely the end of a drainage tube is insinuated between them in such a way as to grasp the whole thickness of the tube By withdrawing the forceps the end of the tube is pulled through the abdominal wall. It is important to see that the assistant does not insert the end of the tube containing the side hole into the awaiting jaws of the forceps this end is required in the peritoneum (*Fig* 240). When the tube is in place satisfactorily it is anchored to the skin with a stitch

Other Sites for Drainage.—Drainage through the original incision certainly should be avoided in the case of a paramedian incision for as soon as the tube has been removed the rectus muscle will form a flap over the drainage hole if the rectus is split, this objection is over ruled. Likewise direct drainage can often be obtained through a transverse incision situated over the lesion. An objection to tube drainage through a laparotomy incision is that it weakens the scar Mainly for this reason many surgeons favour drainage through a stab incision whenever possible The objection to a stab incision especially one towards the flank, is that it favours development of cellulitis in the abdominal wall in the vicinity of the stab.

A drainage tube should always be so placed that there is a straight course for the pus to escape *to the exterior; this should be the guiding principle of its placement—not* whether the tube passes through the incision or through a counter incision

ISOLATING THE UPPER FROM THE LOWER ABDOMEN FOR DRAINAGE PURPOSES

The entire supracolic area of the peritoneum can be isolated from the infracolic area by suturing the greater omentum to the abdominal wall. The calls for this in emergency surgery are few examples are (1) cases of extensive rupture of the liver where seepage of bile is certain to occur (2) when the peritoneal cavity is opened accidentally while draining a subdiaphragmatic abscess.

ALTERNATIVE METHODS OF DRAINING THE PERITONEAL CAVITY

Sump Drainage.—To remove purulent fluid from the bottom of a cavity e.g the rectovesical pouch, as soon as it arrives there is appealing especially when at operation a large quantity was removed by suction, and more is likely to form. Sump drainage fulfils this desideratum. The partial vacuum created by the pump encourages free fluid to flow towards the sump With a Stedman's fitting attached to a fairly large intraperitoneal suprapubic drainage tube sump drainage can be carried out via a small catheter connected to a suction pump (*Fig* 241)

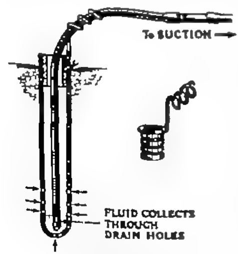


Fig 241.—Sump drainage with a Stedman's fitting

Cleland's Sump Drain[1] (*Fig* 242) is made of Portex vinyl ether—a flexible plastic that allows the outer or sump portion of the drain to bend with the movements of the body The inner tube is held in position by a collar tight enough to prevent the inner tube from falling out during sterilization, yet loose enough to allow it to be removed for cleaning The tube is made in two sizes.

After 48 hours the stitch retaining the outer tube of a sump drain should be cut, and the tube turned.

Fig. 242.—Cleland's plastic sump drain.

The Penrose Wick Drain consists of ½-in. Penrose soft latex tubing (which in texture is like small Paul's rubber tubing) containing a wick of gauze (*Fig* 243) The technique of its placement and the length of time it remains in situ differ so much from ordinary

[1] Portland Plastics Ltd., Bassett House Hythe Kent.

tubing that the following details should be studied closely. Being non-rigid, the Penrose wick drain is suited particularly to draining the peritoneal cavity through the original incision (*Fig* 244). In early peritonitis only one drain is used; usually, however, especially in cases of more extensive peritonitis, two drains are employed. As Reynolds points out, if two Penrose drains are placed together many folds develop between them; these folds result in spaces that are free from encircling omentum and coils of intestine, so that along

Fig 243.—A Penrose wick drain.

these spaces intraperitoneal exudate is likely to find its way to the exterior. The surgeon must replace all viscera in the position they are likely to occupy during convalescence before the drains are inserted, otherwise they are liable to become kinked and ineffective. Tight closure of the abdominal wall around these drains occludes the lumen of the potential spaces alluded to. Likewise, Penrose drains are rendered useless if they are placed through small stab incisions. In order to function fully the opening about the drain should admit the tips of two fingers readily. To ensure that the drains remain at the site they are expected to drain, they should be anchored to the nearest point of the fatty tissue of the abdominal wall. For this purpose a very fine (No. 1) plain catgut is used. The drain cannot then be removed with ease for six or seven days. In the occasional case when it is found to be still anchored for more than seven days but the patient is fit to return home he may be allowed to do so and the drain or drains are removed at a subsequent visit. The absolutely non-rigid character of these drains renders them incapable of causing pressure necrosis, and they can remain in the peritoneal cavity for a comparatively long time with absolute safety. The drains are not disturbed until the patient is afebrile or nearly so, and then they are removed in stages. As a rule removal is commenced on the sixth or seventh post-operative day, but if the patient is pyrexial at this time removal of the drains is postponed for as long as the pyrexia persists. Shortening of them can commence as soon as they are loose.

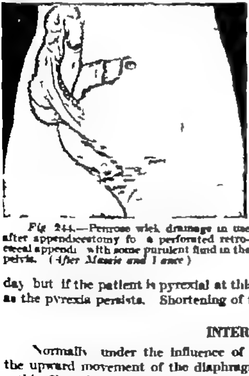


Fig 244.—Penrose wick drainage in use after appendicectomy for a perforated retrocæcal appendix with some purulent fluid in the pelvis. (*After Massie and Lane.*)

INTERNAL DRAINAGE

Normally, under the influence of decreased intra-abdominal pressure occasioned by the upward movement of the diaphragm during expiration, aided by capillary attraction, a thin film of peritoneal fluid travels continuously in an upward direction to the subdiaphragmatic spaces. Experimental evidence shows that the fluid, together with coloured particulate matter (and bacteria), is absorbed avidly by the subdiaphragmatic peritoneum, and passes into the subperitoneal lymphatic network. Particulate matter has been found in the lymph-nodes above the diaphragm after a few minutes.

When there is an outpouring of many ounces of peritoneal fluid and, perhaps, in addition the contents of the stomach or duodenum escape into the peritoneal cavity through a perforation, it is extremely doubtful if the forces just described can counter-balance the influence of gravity. In all probability excess of free fluid within a peritoneal cavity unobstructed by adhesions, given the opportunity, runs downwards.

After the abdomen has been opened, air enters, and if the patient is nursed in a sitting position, which is usual the entrapped air obeys the laws of gases and comes to lie under the diaphragm where it can be demonstrated radiologically, until it is absorbed The same phenomenon is seen in many cases of perforated peptic ulcer air having entered through the

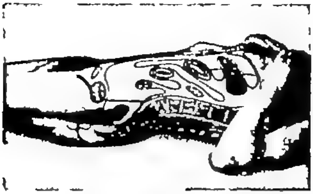


Fig 245.—Common disposition of pools of exudate when a patient is kept in the horizontal position.

perforation. So long as an air lock remains beneath the diaphragm the normal upward current of peritoneal fluid is not operational In these circumstances, and when the amount of fluid is too great for it to be absorbed quickly it obeys the laws of gravity and pools in dependent portions of the peritoneal cavity (*Fig* 245).

POSTURE, WITH SPECIAL REFERENCE TO FOWLER'S POSITION

In cases of peritonitis, it is obviously most desirable to favour the pooling of purulent fluid in the pelvis (*Fig* 246) or if the infection originated in the lower abdomen, to prevent it spreading in an upward direction. There can be no possible objection to Fowler's position—even high Fowler's position—in the case of a child with peritonitis. So great an authority as Gross, of the Boston Children's Hospital, emphasizes that children are almost immune to phlebothrombosis decubiti and he employs this position. In adults with peritonitis, during the first 48 hours after admission it is highly desirable to take advantage of the benefits of Fowler's position, provided it can be maintained without undue risk of encouraging venostasis in the lower extremities—and given the services of a special nurse, it can.

Fig 246.—When the aid of gravity is invoked, in the absence of adhesions, much of the exudate gravitates to the pelvis.

Nursing Details.—

Propping up is accomplished by five pillows, but four will be sufficient if a back rest is employed. Many surgical beds are provided with an adjustable back rest. Of all the pillows, the one behind the neck is the most important to the patient It must be so arranged as to support the neck without any muscular effort.

Preventing slipping down is the major problem and requires considerable personal attention and determination to provide the best means of support. An extremely good method, which in no way retards venous return from the lower limb is a well padded board 8 in. (20 cm.) wide and as long as the breadth of the bed. To have two boards of this size bolted together with right angled metal brackets aids stability Then comes the difficulty of providing for the various lengths of leg The simplest and best method is to have a hole bored in each end of the vertical (padded) board, pass a length of strong blind cord through each hole, and tie the cords to the corresponding side of the bedhead. The position of the board can then be adjusted to meet the particular patient's requirements (*Fig.* 247). Even an ill patient can brace himself against the board. A small soft pillow should be placed beneath the heels, to relieve pressure in this situation. When no board can be procured in time, a wooden box at the foot of the bed (*Fig* 248) is a satisfactory makeshift. A very ill patient may be unable to brace himself against the foot support. If after

lifting him up on three or four occasions, it is found that he soon slips down again, the position should be abandoned.

Elevating the head of the bed In high Fowler's position, 18-in. (45-cm.) wooden blocks are placed beneath the legs of the head of the bed In low Fowler's position, 6-in. (15-cm.)

Fig 247.—An adjustable padded footboard to prevent the patient slipping down in bed.

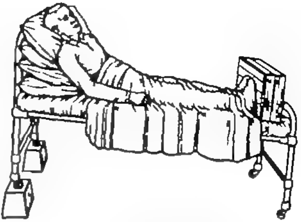


Fig 248 —A wooden box at the foot of the bed t prevent the patient slipping down.

blocks are used. Better than blocks is an adjustable fitting supplied by Hoskins & Sewell, of Birmingham. This bed lifter (see *Fig* 101A) can be attached to any bedstead, and permits the bed to be wheeled about without alteration of the patient's position. According to whether the peritonitis is diffusing or more strictly localized, high or low Fowler's position is chosen. The high position is not required after 48 hours, and the low position

Fig 249 —The semi-recumbent position aided by blocking the foot of the bed.

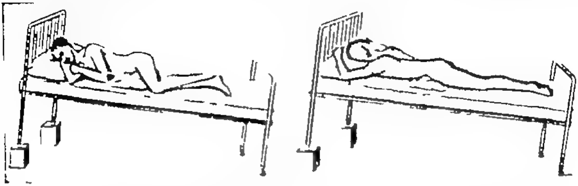
can often be abandoned after three days, when it can be presumed that localizing adhesions have formed. The patient can then lie in the position he finds most comfortable but the sitting position is to be preferred, as it facilitates respiration, feeding and reading To prevent the patient slipping down, the foot of the bed can by this time be safely raised on 4-in. (10-cm.) or 6-in. (15 cm.) blocks (*Fig* 249). This has the advantage of aiding venous return from the lower extremities.

Other Expedients for invoking the Aid of Gravity—

Lateral Decubitus.—In the case of drainage of an abscess localized in an iliac fossa, or when Rutherford Morison's pouch has been drained through a counter incision in the absence of suction drainage the patient should be encouraged to lie on the affected side by placing a pillow under the opposite loin. By this means the aid of gravity is invoked.

Prone Postural Drainage—The prone position of draining the peritoneal cavity should be used *more often*. Obviously it is mechanically sound. As seen in *Fig* 250,

the left leg is flexed slightly and the right leg is straight. The patient lies in this position from a half to three hours, and in many cases of pelvic peritonitis pus literally pours out of the suprapubic drainage tube Another great advantage of the prone position is that it admits of considerable variation in posture (*Fig* 231) These changes do much to relieve the weariness of any fixed position and obviate the ever present menace—venostasis and thrombosis.



Figs. 230 231 —Methods of combining prone and Fowler s positions.

Additional Aids in preventing Phlebothrombosis Decubiti.—By ordering the legs to be exercised from the very first day of a patient being nursed in Fowler's position and also prescribing pulmonary gymnastics, and by seeing that these measures are carried out faithfully the surgeon will be spared a number of cases of pulmonary embolus.

In well-equipped clinics it is possible to order the desirable massage and pulmonary exercises to be carried out by especially trained personnel To those without these facilities, the following simple formula will be found useful and effective. Ask the nurse in charge to see that the patient draws up each leg three times a day and then takes three breaths and fills his lungs to the uttermost. If the patient is well enough, in order to impress these instructions upon both the patient and the nurse say " Nurse will not give you your meals until you have done your exercises "

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CHAPTER XIX

GASTRIC, DUODENAL, AND INTESTINAL ASPIRATION

GASTRIC ASPIRATION

No patient should be allowed to suffer the misery of repeated vomiting. In intestinal obstruction, paralytic ileus, peritonitis, acute dilatation of the stomach, post-operative vomiting, and indeed in all conditions where vomiting is repeated, the stomach content is watery and can be aspirated easily. Only in comparatively rare instances, where both nasal passages are obstructed, is it necessary to employ the oral route. There is a wide field for the application of gastric aspiration. The practitioner might well carry an aspirating tube and use it in the patient's home, for instance, before a patient with intestinal obstruction, or a perforated peptic ulcer, is transported in an ambulance. Gastric aspiration can, if necessary, be continued during an operation (*Fig* 252).

Fig 252.—Continuous gastric aspiration during operation for intestinal obstruction under spinal anaesthesia.

In this country, usually a Ryle's tube (*Fig* 253) is employed; the Levin tube (*Fig* 254) is used widely in the U.S.A. My gastric aspiration tube[1] (*Fig* 255) was designed to empty the stomach by the nasal route when this measure was required urgently. The tube is a little easier to pass than a Ryle's tube, for in the distal end there is a coiled spring that *helps to stiffen it. Rubber tubes* should be sterilized by boiling. A Portex[2] polythene gastric aspiration tube has the advantages of being less irritating to the nasal passages and, unlike rubber, does not perish in a hot climate. Its disadvantage is that after boiling it is too soft to pass until some time after it has cooled. If sterilized by boiling and then stored, it is too stiff to pass with safety and it must be softened in hot water and allowed to cool to the required pliability.

[1] Made by the Genito-Urinary Man. Co., 28a, Devonshire Street, London, W 1.
[2] Portland Plastics Ltd., Bassett House, Hythe, Kent.

Passing the Tube—The tube is lubricated with liquid paraffin The nasal route for the passing of the tube is much the better There are occasions when nasal obstruction prevents this route from being chosen but they are comparatively infrequent The alternative route (the mouth) must then be utilized, but an indwelling tube through the mouth is liable to cause nausea and other discomforts In addition the patient is inclined to chew the tube whereas once the tube is in place via the nose it can be tolerated with minimum discomfort

Choosing the nostril which is the more patent and having cleansed it the bulbous end of the tube is pushed along the floor of the nose The passage past the turbinates is assisted by tilting the tip of the nose upwards with the left finger and thumb. Retching occurs instruct the patient to swallow If he continues to retch, instruct him to sip and swallow some water a glass half-filled with water should be at hand Once the end of the tube has passed the level of the cricoid cartilage as a rule the tube can be passed onwards easily That the end of the tube has reached the stomach can be ascertained by the aspiration of gastric contents. If little or nothing is aspirated, put the end of the tube near the ear If by mischance the tube has entered the trachea, blowing will be felt and heard.

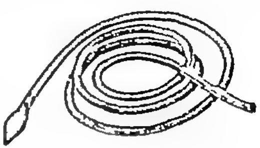

Fig 233.—Ryle's tube

Fig 234—The Levin tube

In cases of intense rigidity of the abdominal wall due to acute peritonitis, notably perforated peptic ulcer it should be realized that the diaphragm and its crura are also tonically contracted so much so that the latter may tightly embrace the lower end of the œsophagus. If there is reasonable doubt as to whether the tip of the gastric tube is within the stomach and facilities exist, a radiograph with a portable machine will settle the doubt.

Refinements in Technique—While a gastric aspiration tube is usually passed without anæsthetizing the mucous membrane it traverses, there is much to be gained by adopting a less crude method (*Figs.* 236–261). The additional trouble entailed brings a rich reward. All patients experience less discomfort the tube can be inserted more often in the case of a nervous patient, who would otherwise create formidable or insurmountable obstacles to its passage rhinitis, initiated by trauma, and its attendant evils are minimized. When the end of the tube has been proved to be in the stomach, withdrawal of it for 2 in (5 cm.) will allow the portion in contact with the nasal mucous membrane to be smeared with sulphanilamide ointment or better aureomycin cream 3 per cent. The tube is then advanced again for 2 in. and the ointment is carried into the nose. Each day the tube should be pulled down, cleansed, lubricated with the cream advanced again, and fixed in position. The surgeon is urged to make it a standing order that the portion of the tubing in contact with the nostril is kept smeared with one of these ointments.

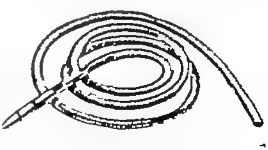

Fig 235—Hamilton Bailey tube

Fixing the Tube in Position.—Once the tube is in place satisfactorily it can be strapped to the cheek with adhesive plaster

Special Cases.—

Unconscious Patients (without a swallowing reflex)—The easiest way to introduce the gastric aspiration tube in an unconscious patient is to pass a Magill's tube well lubricated both inside and out, past the pharyngeal sphincter The gastric aspiration tube is passed down the Magill's tube When the former has reached the stomach the latter is withdrawn

Fig. 236.—The patient sits up with his head supported at the angle shown. The wider nostril is cleaned and the nostril is packed with wool soaked in 2 per cent anethaine.¹

Fig. 237.—2 ml. of anethaine are poured into a medicine glass; the patient gargles the solution for half a minute and then swallows it.

Fig. 238.—A tumbler of water is handed to the patient. The tube is passed down the nostril after the cotton wool has been removed. Steadying the patient's head while he drinks, the tube is passed onwards.

Fig. 239.—As soon as it is judged that the end of the tube is in the stomach, the sister is asked to attempt aspiration. If fluid is not withdrawn, the tube is passed on farther.

Fig. 240.—*Once the tube is satisfactorily in* place it is fixed to the cheek with adhesive plaster.

Fig. 241.—*Aspiration* is continued. The patient drinks the remainder of the water in the glass, which is aspirated promptly and this helps to wash out the stomach.

¹ Anethaine (Glaxo Laboratories, Greenford, Middlesex).

(Franklin Evans). That the tube has reached the stomach and has not entered the trachea, is proved by aspirating gastric contents. On the other hand, if nothing is withdrawn listen at the end of the tube for a blowing sound impingement of air on the ear is proof positive that the tube has entered the air passages. This point which seems insultingly elementary must never be forgotten while intubating the unconscious.

Refractory Non-co-operative Patients.—Efficient surface anesthesia (*see above*) reduces the number of failures by at least 30 per cent If this fails, sodium luminal, 3 gr intra muscularly should be injected 20 minutes before attempting to pass the tube

Emptying the Stomach, and Keeping it Empty —Aspiration can be carried out by any well-fitting syringe for instance a Janet s 6-oz. (180-mL.) syringe with a metal plunger is often admirable for the purpose The use of the adaptor illustrated in *Fig* 262 allows the end of any pattern of gastric aspiration tube to be fitted to a Record syringe with such accuracy that there is no loss of suction.

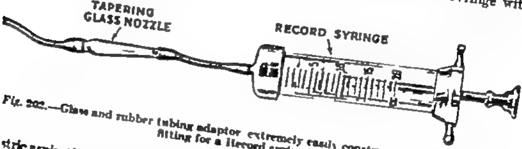

Fig. 262.—Glass and rubber tubing adaptor extremely easily constructed, makes a perfect fitting for a Record syringe

Gastric aspiration should be done ***only by hand*** an electric suction pump Wangensteen s apparatus, and other mechanical devices can never replace a special nurse A gastric aspiration tube is liable at any time to become blocked, most frequently by gastric mucosa being sucked into the eyes of the tube and it requires immediate human attention to keep it patent without such attention the patient s life is in jeopardy

Measuring the Fluid aspirated.— All fluid aspirated must be measured and charted. It is necessary to instruct the nurse as follows assume that the gastric aspiration tube was passed at 9 a.m. The patient is allowed 1 oz. (30 ml.) of fluid each hour All the material aspirated from the stomach is collected in a bucket. At any 8 p.m. the contents of the bucket are measured and the amount he has drunk is subtracted therefrom. This will give the total quantity of regurgitated fluid during that six hours. This is charted and the same procedure is adopted for the next six hours.

When should the Tube be Removed? As a rule at the end of 48 hours. There are many occasions when obviously the tube should be boiled and re inserted within half an hour There are other occasions where it is judged that its function can be dispensed with in which event it is wise to warn the patient that if he experiences nausea he must report the matter at once. Should he do so or if the nurse hears even a muffled hiccup, she must be prepared to re-insert the tube. There are still other occasions when it is essential to know whether antiperistalsis is proceeding i.e., whether the patient would vomit if the tube was not in place considerable help can be obtained from what may be called a gastric motility test

The Gastric Motility Test.—The patient is asked to drink ½ pint (284 ml.) of barley water coloured with cochineal or indigo-carmine If after 1½ hours, none of this coloured fluid can be aspirated it is proof positive that the stomach is passing its contents onwards and aspiration is no longer necessary

INTESTINAL ASPIRATION

Intestinal aspiration is a boon in the preparatory stages of acute or chronic intestinal obstruction and a life-saving measure in paralytic ileus. The dangers of its pre-operative employment for more than a few hours in acute intestinal obstruction, and for less or not at all, if strangulating obstruction cannot be ruled out, are set out on p 413.

Intestinal Intubation with a Miller Abbott Tube —The Miller Abbott tube (*Fig* 263) is of considerable length, and has its lumen double throughout, viz.  The small channel is used to inflate the balloon, the larger to aspirate the intestinal contents. A new bag is required for each patient. The bag must not be tied too tightly or it will obstruct the lumen

of the tube There are a number of marks and numerals along the length of the tube The only ones of real importance are 45 (–) 60 (=), and 75 (≡).[1]

Testing the Tube.—Syringe water through the compartment of the tube which is to be used for suction. Inflate the bag with 20 ml. of air and observe whether inflation is maintained. If you are doubtful test the bag for leaks under water using moderate pressure. Having completed these tests, deflate the bag

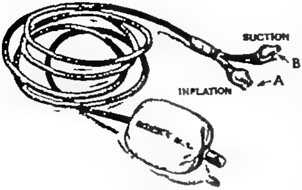

Fig. 263.—The Miller Abbott tube The tube is made by G. P Pilling & Son, Philadelphia. The nipples A and B do not fit British-made syringes. Messrs. John Bell & Croyden Ltd. Wigmore Street, London, have altered these nipples so that A fits a Record syringe and B a Janet s syringe

Marking the Tube—The approximate distance from the patient s nostril to the pylorus is estimated, and marked on the tube with ink

Rendering the Tube surgically clean—It is not essential to have the tube sterile, but it should be as clean as it can be made without injuring it. Wash it in soapy water rinse in plain water and then immerse it in spirit for five minutes. Allow the spirit to evaporate before use

Surface Anæsthesia (see p. 100) is most *desirable in this instance*

Method of Passing the Tube through the Nose.—Even a collapsed bag is bulky The following expedient simplifies the passage of the bag through the nose A Ryle s tube is passed until the bulbous tip can be seen or felt in the pharynx It is grasped with a long hæmostat and brought out through the mouth (*Fig* 264)

The metal end of the Miller Abbott tube fits the butt-end of the Ryle s tube snugly Thus attached, the bag lubricated with liquid paraffin, can be piloted down the nose into the pharynx and out of the mouth by pulling on the forward end of the Ryle s tube which is then disconnected. The patient is given a short rest and a little water to drink Several inches of the nasal end of the Miller Abbott tube are lubricated. Grasping the tube between the finger and thumb about 1 in (2 5 cm) above the bag the tip is *directed into the commencement of* the œsophagus while the tongue i hooked forwards with the left index finger Quickly the left hand takes on the role of advancing the tube *in the pharynx while the right pulls* on the tube entering the nose Thus the mouth is cleared of slack. If the patient brings up the bag the process *must be repeated* There should be no undue difficulty in

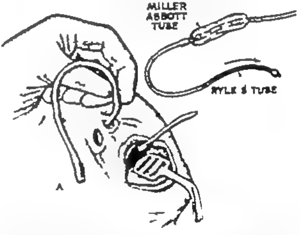

Fig 264 — A method of passing the bag of a Miller-Abbott tube through the nose A Ryle s tube is passed as shown. I to the butt end, A, of the Ryle s t be fits the metal end of the Miller Abbott tube Firm continuity of the two t bes is thereby est blished (inset).

getting the bag into the œsophagus, and if the patient drinks the bag will be carried down by peristalsis, as can be seen by the well lubricated tube being drawn into the nose without the assistance of the operator *Once the tube is in the stomach it is filled with 30 ml* of air and is drawn back until the balloon i felt to come up against the cardiac orifice The balloon is deflated and advanced until the 45 (–) mark is at the nostril The patient is turned on to his right side with his left knee drawn up. He should drink water at frequent intervals. A proportion only of *this fluid is aspirated. When the stomach contains fluid it is traversed* more easily by the tube and the pylorus is more likely to be open The difficult part of the

[1] 45 (–), 60 (=), 75 (≡), refer to cm. measured from the tip of the tube

intestinal intubation is to get the tip of the tube through the pylorus It has been accomplished in twenty minutes, but it may take 24 hours. *Figs* 205–207 should be studied at this juncture With the patient partaking of water at frequent intervals, and the bag deflated, the contents of the stomach are aspirated. If the tube becomes blocked irrigation is employed. While this is going on, the deflated bag is slowly but steadily advanced 1 in. (2 5 cm.) every 10 minutes, keeping the entering tubing well lubricated. It is advanced

Fig 205 —With the tube in this position—

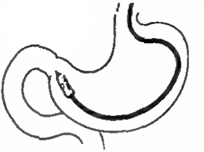

Fig 206.—There is enough slack to allow the bag to enter and pass the pylorus.

Fig 207 —When too much tubing is passed into the stomach it spells failure for the reason that is obvious.

until it is judged by the mark made on the tube previously that the pylorus has been reached usually this is between the 60 (=) and the 75 (≡) cm mark. In order to prevent the temptation of pushing in too much tubing the tubing should be strapped to the nose (not the cheek) with adhesive plaster Now is the time for patience Every half hour the balloon is inflated with 10 ml. of air and one tries the tension on the tube for the hoped for tugging sensation which signifies that the bag has passed the pylorus. The aspiration of undiluted bile or intestinal contents—undiluted by the water the patient is imbibing—also signifies that the tube has passed the pylorus. If the bag has definitely passed the pylorus, inflate with a further 15 ml of air making 25 ml. in all.

The Pylorus cannot be Negotiated —Try replacing the air in the tube with 10 ml. of water and wait for 1–2 hours. The additional weight sometimes favours the passage of the bag through the pylorus. Another excellent expedient is to fill the deflated bag partially with 2–3 ml of metallic mercury 10–15 ml. of air is necessary to drive the mercury into the bag the air is then aspirated When either of these expedients is used it is necessary to withdraw the tube to the 45 (—) mark and the whole process of advancement is repeated. If these measures fail the tube will have to be left in the stomach as a gastric aspiration tube.

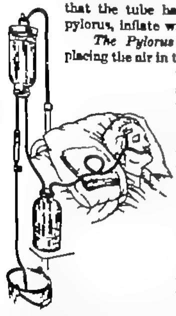

Fig. 208.—Continuous intestinal aspiration by hydrostatic negative pressure. (*After Rodney Smith.*)

Fig 209 —Radiograph of the Miller Abbott tube in position in the ileum. In this case the patient had a barium enema and also barium had been injected down the tube. In this way the actual point of obstruction is demonstrated.

When a portable X ray apparatus is available far less skill and patience are required. The first thing to do is to manœuvre the tube into the position shown in *Fig* 206. Probably the bag will then be carried through the pylorus in a few hours, provided the amount of tubing inserted into the stomach is not sufficient to allow coiling in the wrong direction.

The pylorus has been passed The inflated bag is kept inflated. The patient is allowed to swallow about 6 in. (15 cm.) of the tube every half hour aspiration being carried out at frequent intervals. As gas and fluid are sucked out of the gut the intestinal walls contract and, regaining their tone, force the balloon onwards. In order that there should be no obstacle to the feeding of the tube into the nose, it is supported by a loop of tape fixed to

the forehead by adhesive strapping (*see Fig* 268). In this way the tube is carried down to the point of the obstruction (*Fig* 269) or in the case of paralytic ileus, to the inactive segment of gut which it is so vital to empty The tube can be left in place for days, if necessary

Continuous Intestinal Aspiration.—Provided it is very carefully supervised by the nursing staff, continuous intestinal aspiration can be employed. The negative pressure water pump (*Fig* 268) can readily be constructed, and answers the purpose admirably

Removing the Tube.—As with the gastric aspiration tube there should be no haste in withdrawing it. The tube can remain in position without aspirating the contents, and only when it is evident that a relapse is improbable is the tube removed. The bag is deflated, and with gentle traction the tube is withdrawn slowly taking about ten to fifteen minutes over the process.

INTESTINAL INTUBATION WITH A CANTOR TUBE

The Cantor tube is a single-lumen tube with a large internal diameter—18 F The holes in the side of the tube are oval in shape, and very much larger than those in the Miller Abbott tube this renders blocking of the tube by particulate intestinal matter most unlikely

Fig 270.—The balloon end of the Cantor tube. (Actual size.)

To the tip of the tube is cemented a rubber bag $2\frac{1}{2}$ in. (6 25 cm.) long (*Fig* 270). The tube which is radio-opaque, is calibrated thus 17 in. (42 5 cm.) from the balloon end of the tube there is a marking S (when the marking S appears at the naris the tube has reached the stomach) Six inches (15 cm.) beyond this is the second marking P (pylorus) 6 in. beyond P there is a third marking D (duodenum). When the marking D appears at the nose there is sufficient tubing to carry the balloon through the duodenum. From that point onwards the tube is calibrated in feet.

Preparing the Tube for use.—

1 Employing a 10-ml. syringe mounted with an 18-gauge needle 5 ml. of mercury is injected into the balloon through the last lateral hole

2. All the air in the balloon is aspirated with the syringe immediately after injecting the mercury

3 The stylet of a [illegible]-gauge needle is passed through the last lateral hole until it reaches the interior of the balloon. A piece of braided silk is wound around the tube twice, over the place where the bag is cemented to the tube. It is tied very tightly When the stylet has been removed there is a minute opening through which gases, but not mercury can escape. The end of the tube is dipped in liquid paraffin.

Preparing the Patient, and Passage of the Tube.—

1 Morphine, $\frac{1}{4}$ gr and atropine, $\frac{1}{100}$ gr are administered half-an-hour before the tube is to be passed. The side of the nose chosen for the passage of the tube is anaesthetized as described on p. 196. The balloon is grasped between the thumb and the index finger permitting the mercury to run into the neck of the balloon. The bag is folded into a cone and with the patient sitting and the head hyperextended, the bag is passed into the nose as far as it will go. Releasing the digits permits the mercury to run into the distal end of the bag

2. When the balloon has dropped into the nasopharynx the patient, sitting upright, takes one drink of water with the result that the balloon passes rapidly into the stomach, and the letter S is seen at the nostril. The contents of the stomach are aspirated while more tubing is inserted slowly until the letter P presents.

3. The patient is turned on to his right side inclining the face downwards. The foot of the bed is raised 12 in. (30 cm.). This position is maintained for two hours, at the end of which time —

4 The patient is placed in Fowler's position and an additional length of tubing is passed, bringing the letter D to the nose This position is maintained for two hours, during which time another 4 in. (10 cm.) of the tubing is passed.

5 *After a further two hours a radiograph is taken to ascertain the position of the tube*

THE PASSAGE OF AN INTESTINAL ASPIRATION TUBE VIA A GASTROSTOMY (RODNEY SMITH)

From time to time cases are encountered where an intestinal aspiration tube cannot be made to pass the pylorus, yet it is felt that to empty the small intestine by intestinal aspiration is essential for the patient's recovery There are other cases where at the conclusion

of an operation for intestinal obstruction it is most desirable to commence intestinal aspiration with as little delay as possible In either of these contingencies the passage of an intestinal aspiration tube via a stab gastrostomy solves an otherwise extremely difficult problem If necessary the operation can be undertaken under local anæsthesia. In any event the stomach must be emptied by means of a gastric aspiration tube before the operation, and kept empty during the operation.

Operation.—

1 A short upper right rectus-splitting incision is made and the pylorus is displayed.

2. A stab incision is made through the left rectus muscle and the distal end of an intestinal tube with its balloon collapsed, is passed through it and withdrawn through the main incision (*Fig* 271 A).

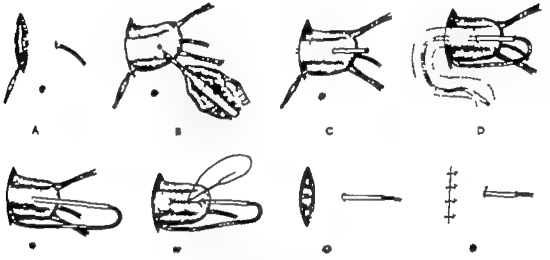

Fig. 271 —Introducing an intestinal aspiration tube through a stab incision in the pyloric antrum. (*After Rodney Smith.*)

3. The pyloric antrum is drawn into the wound, and a stab incision is made 1 in. (2·5 cm.) proximal to the pylorus (*Fig* 271 B).

4 A rigid tube large enough to transmit the intestinal tube and its bag is passed into the stomach and insinuated through the pylorus into the first part of the duodenum (*Fig* 271 C)

5 The intestinal tube is lubricated and passed through the rigid tube onwards until its tip has negotiated the duodenojejunal flexure (*Fig* 271 D)

6. The rigid tube ensheathing the intestinal aspiration tube is partially withdrawn, so that its distal end comes to lie in the pyloric antrum (*Fig* 271 E) The tube in question is fixed in this position with a single catgut suture passing through it and the stomach wall.

7 Four fifths of this tube is now embedded, as in Witzel s gastrostomy (*Fig* 271 F). The suture line is reinforced with interrupted cotton stitches.

8 The stomach is returned to the abdomen, and the slack of the intestinal tube is withdrawn through the stab incision, as also is the unembedded proximal fifth of the rigid tube (*Fig* 271 G). The latter is anchored to the skin by a single stitch.

9 The right rectus incision is closed (*Fig* 271 H)

10. The balloon of the intestinal tube is inflated.

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CHAPTER XX

PERITONITIS

In this chaper we will deal with *principles* in the treatment of diffuse peritonitis and peritonitis of obscure origin, rather than that where the focus of origin is known. One must strive to arrive at a diagnosis, or at any rate a reasoned pre-operative hypothesis, of the source of the peritonitis. Unless a primary focus can be found and dealt with, the outlook is very grave. A correct pre-operative diagnosis and a good anæsthetic are more than half the battle.

Antibiotic Therapy in Peritonitis.—In order to prevent unnecessary repetition in subsequent chapters dealing with special forms of peritonitis, it will be convenient to set out the principles of antibiotic therapy in peritonitis here. Finality has not been reached, and as yet it is a matter of opinion as to which antibiotic or combination of antibiotics is the most efficacious, especially in the absence of bacteriological guidance. Of course, if a specimen of purulent peritoneal fluid has been obtained, and sensitivity tests indicate a certain antibiotic, this is given.

Combined Penicillin and Streptomycin.—For an adult, penicillin 500 000 units and streptomycin[1] 0·5 G., both intramuscularly 12-hourly, have been used extensively with considerable satisfaction. A disadvantage of this dual attack is that resistant strains of organisms develop more quickly than when aureomycin or terramycin is employed.

Aureomycin.—Penicillin and streptomycin, despite their proved worth, fail on occasions to control bacterial peritonitis. Intravenous aureomycin, with its wider antibacterial range, has proved even more efficient in reducing mortality. Prior to the introduction of a buffered aureomycin hydrochloride, the incidence of chemical phlebitis was extremely high. Aureomycin buffered with sodium glycinate has practically eliminated this complication. The method of administration is extremely simple. The powder is mixed with 50 ml. of sterile distilled water and injected directly into a vein, about five minutes being taken to complete the injection.

When the diagnosis of peritonitis is made pre-operatively, 0·5 G. of aureomycin is administered intravenously. Post-operatively 0·5 G. is given twice daily, and continued until the patient's condition has improved to the point where fluids can be taken by mouth. Thereafter the drug is given orally 0·5 G. twice daily.

Aureomycin has proved to be the most effective agent for use in the treatment of peritonitis (Wright et al.). In children the dose should range from 0·3 G. to 0·5 G. intravenously twice daily, depending on the age and the weight of the child.

On no account should aureomycin be given with penicillin, as there is an antagonism between these two substances.

Terramycin, like aureomycin, is a singularly effective antibiotic in the treatment of peritonitis. For an adult 1 G. should be given intravenously every 12 hours for 2–4 days, followed by 0·5 G. orally every 6 hours for a period of 8–10 days. Terramycin has been found to be effective in some severe cases of peritonitis when penicillin and streptomycin have been unavailing after a trial of several days (Reiss et al.).

It should be noted that systemic administration of any antibiotic is completely incapable of preventing the development of either wound infection or fascial slough.

GRAVE DIFFUSE PERITONITIS

When the pulse is feeble and in the neighbourhood of 140, and the abdomen drum-like, or other combination of signs make it undeniable that peritonitis is diffuse, the interests of the patient are served best by adopting a conservative attitude for two to six hours, or even longer, during which time no effort is spared to get him into the best possible condition. The bulwarks of conservative treatment are as follows:—

1. Fowler's position, if the pulse is not too feeble.
2. An hourly or half-hourly pulse-rate.

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[1] Dose for a child 0·25 G. 12-hourly, and for an infant 0·25 G. 24-hourly.

3. Gastric aspiration
4. A plasma infusion followed by continuous intravenous dextrose-saline
5. A circulatory stimulant e.g. methedrine
6. Antibiotic therapy
7. *Blood transfusion preferably with fresh blood is required if the hæmoglobin has fallen below 70 per cent*

As a result of these measures in all but the moribund some improvement in the general condition (*Fig.* 272) takes place. As improvement sets in once again the opportunity is taken of making a clinical examination with a view to determining the primary

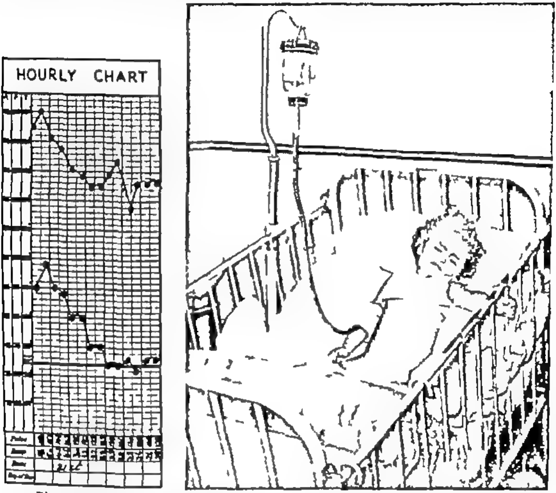

Fig. 272.—Child with diffuse peritonitis. Hourly pulse chart is shown. With intravenous saline solution and Fowler' position improvement occurred and a perforated gangrenous appendix was removed 14 hours after admission. Recovery

focus, if such is in doubt. A plain *radiograph of the abdomen* with the object of demonstrating the presence or absence of gas beneath the diaphragm, is most desirable. When possible, a *serum-amylase test*, to help to exclude acute pancreatitis, should be performed. In cases where there is free fluid in the peritoneal cavity *peritoneal puncture* is a possible means of diagnostic assistance, but it must only be carried out in the manner described on p. 362.

A time has now been reached when the weighty decision whether to operate or not to operate must be made. In the chapters that follow where the source of the peritonitis is not in doubt, e.g. perforated appendicitis, perforated peptic ulcer, acute pancreatitis, etc., this decision is discussed in detail. In this chapter where diffuse peritonitis of doubtful origin is being considered there is little choice. If the patient rallies sufficiently for operation to be undertaken to take the current when it serves undoubtedly gives the patient his best chance. On the other hand when after consultation it is considered that the risk of operation is too great, the Ochsner Sherren treatment of peritonitis (see p. 232) is obligatory at any rate for the time being and in a few cases the infection becomes localized (see *Fig.* 280, p. 215)

We will assume that the patient in question has responded sufficiently to be placed in the category that immediately follows —

Diffuse Peritonitis: Condition of the Patient, Fair —

Quick in, quick out and drain. (J B Murphy)

The first step and one of great importance is to lay a sterile towel on the prepared abdomen and to palpate the abdomen under the anæsthetic. Sometimes this is rewarding—a lump e.g., a mass connected with a perforated diverticulum of the colon, hitherto impalpable, gives the answer to the conundrum "Where is the abdomen to be opened?" When, as is more usual, this examination is negative the best procedure is as follows open the abdomen by a gridiron incision and inspect the appendix. At any rate the appendix can be scrutinized by this route. When the appendix is found to be perforated the search is ended. If the appendix is inflamed but not perforated, perform appendicectomy and pass the organ to someone in the theatre to slit up. *If the appendix is more inflamed on the outside than the inside, the organ is innocent—search elsewhere* By way of a gridiron incision a suprapubic drainage tube can be inserted accurately into the rectovesical pouch after a special suprapubic stab wound has been made.

Unless clinically there is some definite hint as to where to open the abdomen, the foregoing method will be found to be a practical one. A gridiron incision can be performed quickly and, should it prove to be unsuitable, it can be closed quickly

For a reason that will be brought forward presently when it is necessary to make another incision, it is advised to defer the closure of the gridiron incision until the last step of the operation.

Must the Abdomen be re-opened[1] *Elsewhere, and if so Where?*

1. Bile-stained fluid is indicative of a perforated duodenal ulcer At least it is proof positive that the upper abdomen must be opened. Especially when the amount of fluid in the peritoneal cavity is considerable, and no definite food particles are discernible perforated gastric ulcer is a possible cause. In such cases considerable help may be derived from asking the anæsthetist to inject 30–60 ml. of 1 per cent solution of methylene blue down the gastric aspiration tube (*see* p. 272).

2. Through the gridiron incision the last 2 ft. (60 cm.) of the ileum can be examined, and a perforation of the terminal ileum or Meckel's diverticulum can be found, or excluded.

3. The character of the exudate (*see* p. 166) is often a valuable guide If it smells, it is the lower rather than the upper abdomen that should be explored. On one occasion, when there was a quantity of odourless fluid in the abdomen of a muscular man in his thirties, a swab on a holder was passed through the gridiron incision towards the pelvic colon. On removing it, the swab smelt. An incision in the left iliac fossa revealed a perforated diverticulum of the pelvic colon.

4 *In the female it is sometimes* possible to inspect the right Fallopian tube through a gridiron incision, and if the exudate is odourless and wells up from the pelvis, this certainly should be attempted.

5 Consider the possibility of acute pancreatitis, although this should have been ruled out by a serum-amylase test. Sometimes there is a prodigious outpouring of free fluid in this condition, and the fluid is not necessarily blood-stained. It is never milky (i.e., opaque semipurulent) or bile-stained.

If uncertainty still prevails, a right paramedian incision is made equally above and below the umbilicus, and of sufficient size to allow the hand to be passed into the peritoneal cavity By systematically palpating (*a*) the stomach; (*b*) the duodenum (*c*) the gall-bladder (*d*) the pancreas (*e*) the kidneys (*f*) the pelvis and (*g*) the left iliac fossa the causative lesion can often be discovered, and, by extending the incision upwards or downwards, it can be displayed. In the minority intra-abdominal palpation is unfruitful. The incision must then be enlarged, first upwards in the male (to allow inspection of the stomach, duodenum, gall-bladder and pancreas) but first downwards in the female (to inspect the adnexæ and pelvic colon). In both sexes both extensions may be required to make a thorough exploration which must include inspection of the pancreas and an

[1] There are two reasons for advocating two comparatively small incisions (one of which is a gridiron incision) rather than one long paramedian incision. (*a*) If one wound becomes infected, the other does not necessarily do so; (*b*) There is a greater danger of wound dehiscence in one long incision (*see* p. 150).

examination of the whole of the large and small intestine together with its mesentery (for suppurating lymph nodes or a ruptured mesenteric cyst) If nothing can be found to account for a profuse odourless peritoneal exudate one must assume that the case is one of primary peritonitis and a suprapubic drainage tube being in position close the incisions. At what stage of the proceedings this is done must be left to the judgment of the surgeon

Additional Tubular Cæcostomy—Experience has shown that when a patient with considerable peritonitis develops a post-operative fæcal fistula, he usually recovers. This was the starting point of providing a small vent in the cæcum at the conclusion of an operation for widespread peritonitis with much distension Those who employ the method are well pleased with it. Others state that the method has been outmoded by the use of a balloon-ended intestinal aspiration tube However it is so often extremely difficult not only to get the balloon to enter the duodenum, but also for it to be propelled to the lower ileum, that in many circumstances subsidiary cæcostomy should have pride of place.

A portion of cæcum is delivered and isolated by a pack. A purse-string suture is inserted. A small puncture is made with a narrow bladed scalpel and a quarter inch (6-mm.) drainage tube or a rubber catheter with a lumen of the same diameter is pushed into the cæcum. Having anchored the tube to the cæcal wall with a catgut stitch the purse-string is tied. This is followed by two further invaginating purse-string sutures preferably of unabsorbable material

When available the greater omentum is utilized to advantage as shown in *Fig* 273. The free ends of the purse-string stitches are brought out through the greater omentum in the same way as shown in *Fig* 727 p. 523. When the omentum cannot be found easily the peritoneum must be stitched accurately to the cæcal wall close to the tube, using interrupted sutures. The muscles and skin are approximated about the tube.

Fig 273.—Cæcostomy as a subsidiary therapeutic measure in peritonitis.

After-treatment is as important as the operation itself. When possible arrange for a special nurse to take charge of the case. As soon as the pulse permits, the patient is placed in Fowler's position (*Fig* 274)

Gastric aspiration is continued as long as bile or intestinal contents are withdrawn alternatively a balloon-ended intestinal tube can be passed. With the tube in place, the patient is allowed to drink a small quantity (1 oz.) of water occasionally provided the fluid is aspirated promptly If after the tube has been withdrawn, vomiting recommences or the patient hiccups, the tube must be re-inserted. Throughout treatment frequent mouth-washes are given.

Dextrose-saline is administered at the rate of 40 drops a minute In severe cases associated with paralytic ileus when the intravenous route is the only one by which the patient can receive nourishment for several days, the addition of a preparation of amino-acids is valuable for maintaining the patient's strength. As mentioned already blood transfusion is often required.

Charts—A two-hourly pulse chart is recorded graphically The temperature is recorded every four hours. No less important is a fluid intake and output chart, which must be kept for as long as the patient is receiving fluids intravenously An antibiotic chart is also required

Sedative Drugs.—Morphine ¼ gr (16 mg) or omnopon ⅓ gr (20 mg) is given subcutaneously and repeated in six hours if required.

Electrolytic Balance.—When the patient is being sustained by parenteral fluids only careful watch must be kept for (*a*) sodium depletion (*see* p. 33) which is apt to occur as a result of the initial vomiting or subsequent gastro-intestinal aspiration (*b*) potassium deficiency (*see* p 34)

Vitamins, especially B complex and C, should be given parenterally at first, and later by mouth. Antibiotics produce vitamin deficiency, notably of the B complex.

Bowels.—Unless they have been opened naturally, a glycerine suppository followed by a low pressure enema can be given on the fourth day. If however additional cæcostomy has been performed, one is spared the worry of failure of the bowels to act during the first six post-operative days of severe peritonitis.

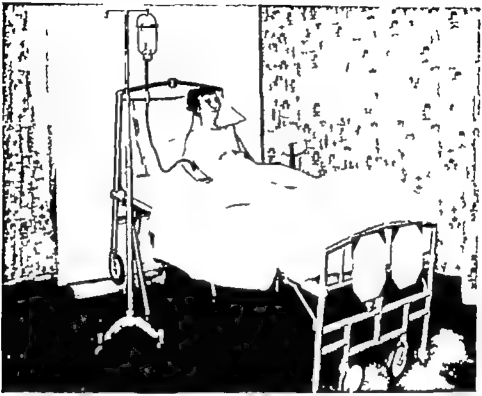

Fig. 274.—The bulwarks of treatment of peritonitis are shown in the illustration. The patient is undergoing treatment after an operation for gangrenous appendicitis with diffuse peritonitis, but the same principles can be invoked in grave peritonitis before operation. Attention should be focused upon: (1) Correct Fowler's position. (2) Transnasal gastric aspiration. (3) Continuous intravenous dextrose-saline. (4) Charts: (*a*) Two-hourly pulse and temperature. (*b*) Fluid intake and output, which is reviewed critically at the end of each 24 hours. The keeping of these charts and the skilful nursing that necessarily accompanies such scientific recordings are the mainstays that may preserve the thread of life.

GONOCOCCAL PERITONITIS

Examples of diffuse peritonitis which appear to arise from gonococcal salpingitis are encountered from time to time. In a number of cases belonging to this category aspirating and/or mopping up the pus, followed by closing the abdomen without drainage and antibiotic therapy, has resulted in recovery. In several of these the pus was sent for culture and was reported to be sterile. This is probably due to the fact that the gonococcus, when removed from its habitat, is a frail organism. (*See also* Chapter XXIII.)

PERITONITIS DUE TO SUPPURATING MESENTERIC LYMPH-NODES

Examples of suppurating mesenteric lymph-nodes giving rise to diffuse peritonitis are not exceedingly rare. A correct pre-operative diagnosis is impossible.

T. W., aged 20, was admitted and gave the following history: while lying down he was seized with violent abdominal pain. There was no vomiting. The pain continued unabated and was all over the abdomen. The pulse was 120 and the temperature 103° F. (39° C.). Rigidity was almost general, but the right upper quadrant was relaxed moderately. The maximum tenderness was in the right iliac fossa. The diagnosis of perforated duodenal ulcer was considered, but it appeared that the temperature of 102° F. (39° C.) made this diagnosis unlikely.

The abdomen was opened by a gridiron incision, and the appendix examined. The organ was removed and slit up. Its mucous membrane was found to be normal. As there was much

turbid fluid in the general peritoneal cavity it was thought that after all the patient had a perforated duodenal ulcer. The gridiron incision was closed and the upper abdomen opened. There was no perforation, but a mass of suppurating lymph-nodes in the jejunal mesentery. Suprapubic drainage. Recovery.

In two other similar cases the same treatment was adopted and both patients recovered: they were males, 27 and 30 years of age respectively.

ACUTE CHYLE PERITONITIS

J. C. Walker's Case.—

A forester aged 27 was admitted with severe abdominal pain of eight hours' duration, which commenced suddenly after breakfast. The physical signs simulated those of perforated duodenal ulcer with extravasation along the right paracolic gutter. It was decided that immediate laparotomy was necessary. On opening the peritoneum the wound became flooded with chyle, of which about 12 oz. (300 ml.) was aspirated. The cæcum was completely white, and the ascending colon patchily so, as if milk had been injected beneath the serous coat. The mesentery of the ileum, the mesocolon, the pancreas, and several small areas on the posterior abdominal wall were affected similarly. A lump was felt behind the stomach. On opening the lesser sac an irregular mass overlying the second and third lumbar vertebræ presented, and from the middle of it there issued a trickle of chyle. A small piece of the mass, which consisted of enlarged lymph nodes, was excised for histological examination. Closure of the leak was effected with difficulty by sewing a piece of detached omentum over the mouth of the opening, and a large Penrose drain was inserted into the lesser sac through the gastrocolic omentum. The wound was closed around the drain.

The pathological report was tuberculous lymphadenitis. It would appear that the mass of tuberculous lymph-nodes caused obstruction to the cisterna chyli. Leakage was due to erosion of a large lumbar lymphatic trunk, or the cisterna chyli itself. The distended lacteals evidently gained a communication with the thoracic duct by collateral channels opening up, for the patient made an uninterrupted recovery, and remained well.

In a collective review on chyle peritonitis Hoffman found that in nearly half the recorded cases the cause of the extravasation of chyle remained obscure. The next most common group occurred in cases of trauma, and this was usually produced by a tear at the base of the mesentery, presumably involving the cisterna chyli. Other causes were as in the case quoted above, or rupture of a chylous cyst. All cases operated upon within 12 hours, recovered. In some, drainage was carried out; in others, after the chyle had been aspirated the abdomen was closed without drainage.

PERITONITIS DUE TO PERFORATION OF THE SMALL INTESTINE

Perforation of the small intestine is comparatively rare, and it is improbable that the correct diagnosis will be made except in trauma and in some cases of typhoid fever. However, the presence of free gas in the peritoneal cavity does make it certain that there is a perforation in some part of the alimentary tract. Without positive radiological evidence, most probably the abdomen will be opened on the diagnosis of perforated appendicitis. If a perforation of the small intestine is found, we should bear in mind :—

1. Regional ileitis.
2. Perforation by an ingested foreign body.
3. Typhoid perforation.
4. Perforated Meckel's diverticulum (*see* p. 264).
5. Perforated primary jejunal ulcer (*see* p. 277).
6. Perforated carcinoma of the small intestine.

Acute Perforation of the Intestine in Regional Ileitis.[1]—Laparotomy reveals diffuse peritonitis and turbid free fluid with large flakes of fibrin. The perforation is found in the thickened terminal ileum. It is usually near the mesenteric border, and is transversely linear. Owing to œdema and friability of the intestinal wall, mattress sutures are the least liable to cut out. The suture line should always be reinforced by a free omental graft. If the condition of the patient permits, a defunctioning ileotransverse colostomy should be carried out, thereby short-circuiting the diseased terminal ileum. Too often, in a matter of days simple suture has been followed by a second perforation. (*See also* p. 230.)

Peritonitis due to a Perforating Foreign Body.—It is not a great rarity to encounter diffuse peritonitis without a definite primary focus. Probably a proportion of these cases

[1] On no account should a piece of the wall of the intestine be removed for biopsy; the intestine is liable to perforate at this point.

is due to perforation of some part of the intestinal tract by an ingested foreign body such as a bristle, which never comes to light. Sometimes the foreign body is large enough and the patient well enough for the lesion to be discovered by a systematic search. In others we may have the good fortune to blunder across the offending object.

J. H., a stout man of 56 was admitted with what appeared to be a typical attack of acute appendicitis with diffuse peritonitis.

A gridiron incision was made and thin pus welled up into the wound. The fingers were inserted into the wound for the purpose of withdrawing the cæcum. This manœuvre was hardly begun when I hastily withdrew my hand, for something had pricked my finger. Further investigation showed that the last coil of ileum had a spiked object sticking through its walls. This was extracted, the perforation closed, and the peritoneal cavity drained. Recovery.

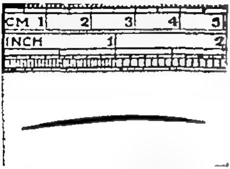

Fig. 275.—A foreign body made of celluloid found perforating the lower ileum in a case of general peritonitis.

The foreign body is shown in *Fig.* 275. It is composed of celluloid. The patient could throw no light on its origin.

Peritonitis from Perforated Typhoid or Paratyphoid Ulcer.—If it is known that the patient is suffering from typhoid the diagnosis is not particularly difficult. I have, however, seen 2 cases in which perforation occurred in a patient with ambulatory typhoid. Perforation occurs most frequently during the second and third weeks of typhoid or paratyphoid fever and operation should be undertaken at the earliest possible moment.

Without operation, within 12 to 18 hours of perforation, the prognosis is practically hopeless. On opening the abdomen, in addition to obvious signs of peritonitis, the distal 3 ft. (90 cm.) of ileum are deeply congested. The perforation is usually found within two feet of the ileocæcal valve, and there may be more than one perforation. Occasionally the perforation is not situated in the lower ileum, but in the appendix, the cæcum, or any part of the colon, including the sigmoid flexure. In rare instances the peritoneal cavity is found to be full of bile, and the perforation is discovered in the gall bladder (*see* TYPHOID CHOLECYSTITIS, p. 314). Exceptionally the peritonitis arises from organisms penetrating the wall of the intestine without perforation (Banks). After closing the perforation or perforations, if such be present, and draining the peritoneal cavity suprapubically the abdomen is closed as expeditiously as possible.

If a course of chloramphenicol has not been started already its administration should be commenced as soon as possible. Chloramphenicol is the antibiotic of choice in the treatment of typhoid. The mortality of perforated typhoid ulcer is very high—over 80 per cent.

Michael Oldfield's Case.—

Perforation occurred on the twelfth day without previous diarrhœa or distension, and was not diagnosed as such until eleven hours after the event, when peritonitis was established. The single perforation 1 ft. (30 cm.) from the ileocæcal valve was closed and the pelvis drained. The post operative course was punctuated by bloodstained pleural effusion, pelvic abscess, obstruction by bands, myocarditis, a mild heat-stroke, and a ventral hernia but the patient recovered.

Primary Perforated Jejunal Ulcer is a rare cause of diffuse peritonitis. Chew Smith collected 35 cases from the literature (*see* p. 283). More rare still is a perforated jejunal diverticulum.

Peritonitis due to a Perforated Carcinoma of the Small Intestine.—I have encountered 3 cases of perforated carcinoma of the small intestine all of which ended fatally. It is probably a mistake to resect in the presence of gross peritonitis. *If* the perforation should be closed by suture and reinforced with omentum, and out later if the patient survives.

Peritonitis due to Intestinal ... **complicating** ... **the Colon.**—Perforation occurs in 4 per cent ... a of the col ... 85 per cent occur at the site of the neoplasm, ... t the cæcum is ... perforation, due to overdistension from obs ...

When the cæcum is perforated ... l by a grid ... that inc has not been employed in the first ... cæcum can ... idly ... should be chosen.

If the cæcum is bound down, the perforation should be closed by liberal plication reinforced with omentum. This is followed by transverse colostomy. In either event, suprapubic peritoneal drainage is essential.

When perforation occurs at the site of the lesion the treatment is similar to that of perforated diverticulitis (see p. 231), a condition which is sometimes difficult to distinguish from a neoplasm. However, there is one fundamental point of difference: neoplasm is always associated with some degree of intestinal obstruction. Whatever course is adopted to stop the leak, the operation should be concluded by performing colostomy well proximal[1] to the lesion. Even with early operation aided by antibiotic therapy, the mortality is not less than 80 per cent.

Peritonitis due to a Perforated Ulcer occurring as a Complication of Ulcerative Colitis.—Perforation of an ulcer into the general peritoneal cavity occurs occasionally in ulcerative colitis, especially *in cases belonging to the fulminating type. If the perforated segment is* mobile it is best cared for by exteriorization. Otherwise, closure of the perforation[2] together with suprapubic drainage and a Penrose drain down to the site of the perforation is the best course. If the patient's general condition will permit a more prolonged operation, ileostomy (see p. 325) should be carried out, more particularly because without it the incidence of re-perforation is high.

ACUTE TUBERCULOUS PERITONITIS

Cases of acute tuberculous peritonitis usually come to operation on account of an error in diagnosis. In some instances it is almost impossible to make a correct pre-operative diagnosis.

Especially in the case of a child with diffuse peritonitis, a leucocyte count of under 10,000 favours acute tuberculous peritonitis. When there is any real doubt as to the differential diagnosis it *is safer to operate*.

If a patient with acute tuberculous peritonitis has a good anæsthetic, no harm is done by opening the abdomen. Indeed, good seems to accrue from removal of the ascitic fluid which accompanies the disease.

On opening the peritoneum a varying amount of free fluid, usually clear and straw coloured, escapes. Tubercles are seen scattered over the peritoneum and the greater omentum. Tubercles may be confused with fat necroses. The latter are more yellow and are often associated with a blood-stained peritoneal exudate. Nevertheless, I have seen a case in which it was most difficult to decide between fat necroses and tubercles until the swollen, purple pancreas was displayed, and left no doubt that it was a case of acute pancreatitis. Again, peritoneal carcinomatosis may on occasions easily be confused with tuberculosis. The tiny multiple deposits of carcinoma feel hard when rolled between the finger and thumb, making their recognition tolerably simple.

On opening the abdomen and finding acute tuberculous peritonitis, a piece of omentum should be removed for histological examination. The abdomen is then closed without drainage.

A troublesome, but rare, complication is the development of tuberculous ulceration in the wound. For this reason, as well as to enable the patient to overcome the tuberculous infection, streptomycin, with its allies isoniazid and para-amino-salicylic acid in correct alternating combinations, is administered as in other forms of tuberculosis.

Other Aspects of Tuberculous Peritonitis in Relation to Acute Abdominal Surgery.—

M. K., aged 21, was admitted with hypogastric pain extending over six days. The pain commenced abruptly, and she vomited twice.

On examination the pulse was 108 and the temperature 100·8° F. (38·2 C.). There was a fullness in the lower abdomen, dull to percussion, which persisted after the passage of a catheter. A rectal examination was negative. A leucocyte count showed leucopenia. A diagnosis of (?) twisted ovarian cyst was made.

Laparotomy showed tuberculous peritonitis, with a loculus containing a pint of clear fluid which was aspirated, and the resulting cavity was mopped dry. The abdomen was closed without drainage. Recovery.

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[1] Some authorities advise that the colostomy be placed immediately above an operable neoplasm, so that later the neoplasm and the colostomy can be excised together.

[2] If, as is sometimes the case, the neighbourhood of the perforation is so friable that it will not hold sutures, partial colectomy with closure of the cut ends, followed by ileostomy, is the best course.

E. H., aged 6, gave a history extending over three days of attacks of colic lasting about three minutes and recurring every twenty minutes. Her mother stated that the child's bowels had not been open, but that a quantity of mucus had been evacuated.

On examination the pulse and temperature were normal, and the child did not appear very ill. There was a lump in the hypogastrium which also could be felt per rectum. An enema yielded a small fæcal result and a considerable amount of mucus. The diagnosis was doubtful. An appendix abscess was suggested, also an anomalous intussusception.

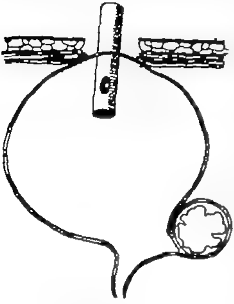

Fig 276.—Marsupialization of a large tuberculous abscess of the mesentery

Laparotomy showed a large tuberculous abscess in the mesentery of the lower third of the ileum. The peritoneum was sewn around the wall of the abscess so as to marsupialize it (*Fig* 276). The abscess was then drained, a large amount of tuberculous pus being evacuated.

Recovery When seen two years later she was perfectly well, but there was some keloid formation in the scar

F J., aged 10, was admitted in a very grave condition with an indefinite history of abdominal pain *extending over five weeks. She had vomited once on* the day of admission. The pulse was 120 and the temperature 100° F (37 8° C.). The abdomen was greatly distended.

On opening the abdomen there was plastic tuberculous peritonitis. Behind the umbilicus there was a cystic mass composed of loops of ballooned small intestine adherent to one another It was impossible to find even one loop of small intestine which was not diseased. Therefore nothing was attempted, and the abdomen was closed, with the resolve to re-open the abdomen should urgent obstruction develop. Unexpectedly she improved after the operation. The bowels moved regularly She was discharged a month later

When written to two years later her mother replied that F J was in a sanatorium and was progressing "quite well

DIFFUSE PERITONITIS FOLLOWING PARTURITION OR ABORTION

When streptococcal peritonitis follows puerperal infection, it is a notifiable disease. It is more common after first deliveries. Rigidity is seldom much in evidence this, at any rate in part, is due to the stretched condition of the abdominal musculature. The lochia may be offensive but not necessarily so. Diarrhœa is common.

When the infection is limited strictly to the pelvis, the Ochsner-Sherren régime (p. 222), followed when necessary by posterior colpotomy (p. 563) is eminently successful. We are considering here a more extensive peritoneal involvement It is the considered opinion of those who have had much experience of these cases that operation should be carried out as soon as possible, even though the patient be very ill. After resuscitative measures and antibiotic therapy have been instituted, the abdomen is opened by a right paramedian incision. When there is an abscess in the wall of the uterus or in the broad ligament, after packing off the area, the abscess is opened with sinus forceps, and a drainage tube is introduced into the abscess cavity should this be large enough to admit one. In any case the peritoneal cavity is drained by *two* drainage tubes passed into the pelvis, one in front of the uterus and the other into the pouch of Douglas.

In the pre-antibiotic era the mortality of general peritonitis following parturition or abortion was at least 50 per cent with antibiotic therapy the mortality has fallen to less than 10 per cent. (Brews.)

IDIOPATHIC STREPTOCOCCAL PERITONITIS IN ADULTS

In nearly every instance primary streptococcal peritonitis is a local manifestation of septicæmia, and the infection is carried to the peritoneum by the blood-stream. However it is possible that in a few cases the infection reaches the peritoneum via the Fallopian tubes. Whereas in secondary peritonitis the peritonitis commences as a localized lesion and becomes generalized, the primary variety begins as a diffuse inflammation and (if the patient lives long enough) becomes localized (Cokkinis). Prior to the antibiotic era,

primary streptococcal peritonitis was nearly always fatal, and the mortality is still very high. Probably appendicitis with peritonitis will be diagnosed. The appendix is found inflamed on the *outside* but not perforated. The peritoneal exudate is odourless, thin, contains small flecks of fibrin, and is sometimes blood-stained. Meteorism may be extreme, causing the condition to be confused with intestinal obstruction In this connexion the following case is of some interest

I was asked to see a woman aged 57 years, who had been admitted to the medical wards as (?) typhoid. She was gravely ill, and the abdomen was greatly distended. There had been no result from an enema, and she vomited small amounts repeatedly

Examination showed a small right femoral hernia. Operation was advised on the diagnosis of a strangulated Richter's hernia.

On opening the sac pus was found within also a small piece of omentum which was reduced readily into the peritoneal cavity She was too ill to warrant anything but drainage, so I passed my finger up the femoral canal and cut down upon it in the suprapubic region. In so doing I pricked my finger In spite of the usual precautions I had a rigor five hours later The pus from the peritoneum grew a streptococcus. The woman died, and at the necropsy general peritonitis was found, but without any demonstrable primary focus. I consider myself fortunate to have escaped with the loss of my left index finger This, of course occurred in the pre-antibiotic era.

Having decided that the peritonitis is idiopathic as much as possible of the pus is removed by suction. After inserting a suprapubic drainage tube the abdomen is closed and measures detailed in the general treatment of peritonitis are carried out.

PRIMARY PERITONITIS IN INFANCY AND CHILDHOOD

(*Pneumococcal and Streptococcal Peritonitis*)

By primary peritonitis is meant there is no focus of infection within the abdomen. In nearly all cases the organism responsible is a pneumococcus or a hæmolytic streptococcus, the latter being slightly more frequent than the former Seventy five per cent of the juvenile patients are under the age of 3 years.

Diagnosis.—The onset is sudden and the earliest symptom is pain localized to the lower half of the abdomen. The temperature rises to 102 F (38 8 C.) or more and there is usually frequent vomiting Should an inguinal hernia be present, it is likely to be distended, but the contents can be reduced readily After 24–48 hours, profuse diarrhœa, occasionally blood-stained is characteristic. There is usually increased frequency of micturition. The last two symptoms are due to the severe pelvic peritonitis. Herpes near a nostril or on a lip is often present. In acute forms of the disease, even in cases where there is no involvement of the lung, there is often a tinge of cyanosis of the lips and cheeks, and movement of the alæ nasi is often discernible. On examination rigidity and tenderness are usually bilateral, but are less marked than that due to appendicitis. When facilities exist, and the patient is a female, a vaginal smear should be examined for the presence of pneumococci Positive findings strongly support a diagnosis of pneumococcal peritonitis.

Primary peritonitis is prone to occur in patients with nephrosis, in which case the infecting organism is nearly always a pneumococcus. Primary peritonitis of childhood is seen less frequently than formerly perhaps this is due to the greater cleanliness and higher standards of living of the poorer classes. The condition tends to be epidemic by this is meant that several cases are encountered within a short space of time

Differential Diagnosis.—A leucocytosis of 30 000 or more with approximately 90 per cent of polymorphonuclear leucocytes favours pneumococcal peritonitis rather than appendicitis. The condition which is extremely difficult to differentiate from primary peritonitis in its early stages is pneumonia. An unduly high respiratory rate and the absence of rigidity are the most important signs supporting the diagnosis of pneumonia, which is usually clarified by a radiograph of the thorax. One must however be mindful of the fact that pneumococcal peritonitis can occur as a complication of pneumonia. Of 8 consecutive cases of pneumococcal peritonitis under my care [illegible] occurred in children who were being treated for pneumonia in the medical wards.

Treatment.—The best plan for the management of a case of primary peritonitis in early life is as follows —

1 A period of preparation for operation, usually a matter of hours. This includes the administration of parenteral dextrose-saline solution, gastric aspiration, the commencement of penicillin therapy and performing compatibility tests prior to blood transfusion

2. A limited operation is conducted under local anaesthesia in the following manner: after a suitable dose of nepenthe 1 per cent procaine solution is injected over the lower right rectus muscle. *An incision 1 in. (2.5 cm.) in length is made* (*Fig.* 277), and after injecting more local anaesthetic into the rectus muscle this is split. With blunt hooks holding aside the wound edges, the peritoneum is exposed, and is opened for about half an inch (12 mm.). With a fountain-pen filler a specimen of the peritoneal exudate is obtained. A hint as to the nature of the infection *can be gathered from the appearance of the exudate* —

Fig. 277.—Under local anaesthesia an incision 1 in. in length is made over the right rectus muscle, the fibres of which are split.

In pneumococcal peritonitis it is odourless, fibrinous, and soapy.

In streptococcal peritonitis it is odourless, thin, contains small flecks of fibrin, and may be blood-stained.

If on opening the peritoneum, the findings indicate that the infection has originated from a perforated appendix, e.g., there is odour, *after a little general anaesthetic has been given*, if required, the incision is enlarged and appendicectomy is carried out. In other circumstances manipulation is reduced to a minimum. On no account should the appendix be removed because its peritoneal coat, in common with the rest of the intestine, is inflamed. Appendicectomy in primary peritonitis increases the mortality. *Excess of purulent fluid is aspirated with a mechanical* sucker, after which a Penrose drain that just fits the incision (*Fig.* 278) is insinuated down into the pelvis. This cigarette drain should be large enough to fill the wound, suture of which is then unnecessary (*Fig.* 279). The patient is returned to bed.

After treatment follows in many respects that detailed for adults. The patient is placed *in high Fowler's position, gastric aspiration is continued, usually for four or five days,* during which time the patient receives intravenous fluid therapy. Blood transfusion is beneficial. For the first 36 hours appropriate doses of nepenthe four-hourly give necessary rest. An oxygen tent is particularly valuable in patients with respiratory distress and/or those (the majority) with abdominal distension. Unless the bac*teriological sensitivity tests* dictate otherwise, penicillin is continued until there is evidence that the infection has been overcome, and thereafter it is given in reduced *doses for four* or five days.

Fig. 278.—A cigarette drain is inserted through the wound into the pelvis.

Fig. 279.—The soft cigarette drain fills the wound and no sutures are necessary. The excess of tubing distal to the safety-pin is cut off. (Ladd technique.)

OTHER CAUSES OF PERITONITIS IN THE NEWBORN

Bacterial peritonitis can be due to :—

1. A blood-stream infection by streptococci, gonococci, or pneumococci.
2. An extension of omphalitis (see p. 179).
3. Perforated peptic ulcer, which is not a great rarity in the neonatal period, whereas
4. Acute appendicitis is extremely infrequent at this time of life.
5. Perforation of a Meckel's diverticulum (see Chapter XXVI).

MECONIUM PERITONITIS

Meconium peritonitis is a non-bacterial chemical or foreign-body peritonitis, usually occurring during late intra-uterine life, but it may occur at or soon after birth. It is due to a perforation, usually in the terminal ileum. In 50 per cent of cases the cause of the perforation is unknown; in 30 per cent it occurs in association with neonatal intestinal obstruction

(meconium ileus, atresia of the ileum volvulus neonatorum) In a number of instances the perforation becomes sealed during intra uterine life, when dense adhesions are the aftermath When the perforation remains patent many of the infants are born dead, or die soon after birth. In those that survive birth the originally sterile peritonitis soon becomes infected when, strictly speaking it is no longer meconium peritonitis.

Diagnosis.—The presenting signs are very like those of intestinal obstruction of the newborn, which indeed is present in half the cases. As a rule the signs develop shortly after birth but when the perforation is secondary to a congenital stricture of the intestine or to bands, the symptoms do not come on for a few days, or even for over a week. When the perforation is recent, shock is pronounced There is also cyanosis, rapid grunting respirations, abdominal distension, bile-stained vomit, œdema of the flanks and scrotum, and occasionally in the absence of obstruction the passage of blood and mucus per rectum. Not all these symptoms are encountered in the same patient, but some of them are always present Radiographs may reveal free gas in the peritoneal cavity In meconium peritonitis, meconium extruded into the peritoneal cavity frequently calcifies, giving rise to a characteristic X ray appearance (*see Fig* 648 p 473) On the other hand less frequently calcification is so slight that it cannot be demonstrated radiologically Free fluid in the peritoneal cavity is often sufficient to give a fluid thrill Franklin and Hosford found that on diagnostic aspiration the fluid withdrawn was bile-stained.

Operative Treatment—Without operation the condition is hopeless. As soon as fluid therapy and gastric aspiration have improved the general condition sufficiently laparotomy is performed In order to expose the lesion usually the surgeon is faced with dissection of a number of dense adhesions Should the case prove to be one of a perforation only this is closed with sutures, and suprapubic drainage of the peritoneal cavity carried out. In cases of perforation secondary to intestinal obstruction, the obstruction must, of course, be remedied as set out in Chapter XLI The mortality in those patients submitted to laparotomy is about 40 per cent.

POST-OPERATIVE PERITONITIS

The incidence of post-operative peritonitis due to infection of the peritoneum at the time of operation is now infinitesimal Nevertheless, because of post-operative intra peritoneal leakage of intestinal contents, bile, pancreatic secretion, or urine post-operative peritonitis is not infrequent. According to Maingot, 20 per cent of cases of peritonitis arise after abdominal operations not performed for peritonitis.

The diagnosis is difficult. Abdominal rigidity one of the mainstays of the recognition of other forms of peritonitis, is frequently in abeyance. Tenderness, though present, is likely to be attributed to the recent incision. Moreover the patient in the early post operative days is permitted, almost as a routine, to have a narcotic for pain consequently he may not register tenderness, or do so in an unconvincing manner The abdominal distension (which in fulminating cases is slight) the diminished or absent bowel-sounds, and the continued aspiration of bile-stained or even fæculent material from the stomach, will most certainly be attributed to paralytic ileus indeed, probably many cases of paralytic ileus *are* due to peritonitis, which may or may not be overcome by antibiotic therapy However no antibiotic can succeed in staying the onslaught of bacterial peritonitis from massive necrosis of the bowel or leakage from a suture line.

The operation which the patient has undergone should serve as a pointer to the possibility of paralytic ileus being due to post-operative peritonitis. Leakage from the duodenal stump after gastric resection leakage from the line of anastomosis after partial colectomy leakage following resection and anastomosis (particularly end to-end anastomosis) of small intestine leakage of bile from a cut accessory duct or from a blow off of a ligature on the cystic duct in the presence of obstruction to the common bile-duct, urine in the peritoneal cavity following leakage from a uretero-intestinal anastomosis or an injury to the ureter or bladder during a difficult hysterectomy are all possible causes of post operative peritonitis, and unless drainage has been provided, or occurs spontaneously through the wound, peritonitis will become diffuse and soon prove fatal.

The diagnosis can only be made after repeated clinical examinations. Antibiotic therapy is likely to control the temperature, and at this time when every scrap of evidence is so important, it tends to mask other signs of peritonitis. However the most valuable of all signs, abdominal tenderness is not so affected, and will surely be present if the

narcotic has been suspended. *Peritoneal puncture* *(see p 1118)* *sometimes clinches the diagnosis.*

Treatment.—In the early stages of post-operative peritonitis drainage to the site of the suspected leak will probably save the life of the patient. If the leak is beneath the incision, removal of stitches and the provision of an opening into the peritoneum, if performed early may suffice. In other circumstances, drainage by the most direct route, as well as suprapubic peritoneal drainage must be instituted as soon as possible.

POST OPERATIVE BILE PERITONITIS

Extravasation of bile into the peritoneal cavity following an operation on the bile-passages occurs in one of the following ways —

1 Seepage through the suture line after exploration of the common bile-duct without drainage of that duct. Leakage through the site of puncture for operative cholangiography has been reported (McKenzie).

2. Blockage or accidental dislodgement of a drainage tube placed in the common bile-duct.

3 Slipped ligature on the cystic duct.

4 Leakage from an accessory duct.

5 Operative damage to the common hepatic duct or common bile-duct.

As far as can be ascertained (1) is the most common It is often impossible to determine the site of leakage when the abdomen is reopened, particularly as the surgeon is anxious to drain the collection and resuture the abdomen as quickly as possible.

McKenzie draws attention to the fact that a stab drainage tube leading to Rutherford Morison s pouch sometimes fails to permit escape of bile due to (*a*) compression of the tube by too small a stab incision, (*b*) the tube becoming blocked with blood-clot or a plug of omentum, (*c*) the tube on occasions becoming kinked when the patient is placed in a sitting position if the stab incision is placed near the costal margin, even if it is well clear of the ribs in the recumbent position.

The lesson to be learned is that in draining Rutherford Morison s pouch by a stab incision, the incision must be of adequate size and placed three fingers breadth below the costal margin.

Post-operative bile peritonitis is often most difficult to diagnose. It should be known that there are two distinct clinical varieties —

a. **Sudden Collapse** within 48 hours of operation. In this type peripheral circulatory collapse overshadows all other clinical features. Internal hæmorrhage or extravasation of bile suggests itself as the cause of the catastrophe If the condition of the patient improves with intravenous dextran, plasma, or preferably blood it is likely that some physical signs will be elicited in the abdomen. In only 2 of 7 cases reported by McKenzie did the patient s condition improve sufficiently to permit re-opening the laparotomy wound. These patients recovered with drainage In the remainder death occurred within 24 hours of the onset of symptoms. In a case of bile peritonitis following cholecystectomy Ivor Lewis reopened the abdomen within 24 hours and inserted a drainage tube. Rapid improvement after the second operation was almost as striking as the rapid deterioration after the first.

b **Insidious Onset.**—Shock is absent. In some cases the symptoms are so mild and the signs so indefinite that there is a considerable delay in establishing the diagnosis. Otherwise unexplained tachycardia with vomiting and abdominal distension coming on several days after an operation on the bile-passages should call to mind the possibility of bile peritonitis. In nearly all cases there are recurrent attacks of abdominal pain. In about half the cases there is some degree of abdominal distension. In only a quarter of the cases is there tenderness, and rigidity is most exceptional. In a quarter of the cases mild jaundice[1] is present. Signs at the base of the right lung, and X ray evidence of raising of the diaphragm, suggest a subdiaphragmatic collection of bile. When considering the diagnosis of post-operative bile peritonitis the total absence of drainage from a tube, if such be present, or a copious drainage of bile that ceases abruptly is most suggestive. Of 10 cases belonging to this group, there were 2 deaths, in neither of which was secondary drainage established.

Summarizing.—If there are reasonable grounds for suspecting intraperitoneal extravasation of bile, there should be no hesitation in reopening the abdomen and if free bile is present establishing local and, if necessary suprapubic peritoneal drainage

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[1] Greenish discoloration around the umbilicus is a helpful sign, when present

RESIDUAL ABSCESS

A residual abscess (*Fig* 280) may occur after successful treatment of diffuse peritonitis by non-operative means. More often such an abscess arises as a complication after an operation for peritonitis. When a localized intra peritoneal collection of pus is suspected excluding subdiaphragmatic abscess, operation should be delayed. When palpable the limitation of an intraperitoneal inflammatory mass should be marked out on the skin, and examined carefully each day

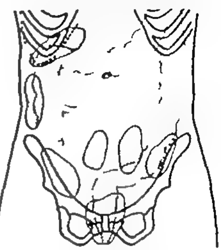

Fig 280.—Sites of residual abscesses. (*After Cutler*)

In a number of instances, with the aid of antibiotic treatment the mass becomes smaller and smaller and is finally impalpable In other cases, if one waits, the limitations of the abscess become discrete and in many situations the abscess becomes adherent to the abdominal wall, so that it can be drained without opening the general peritoneal cavity

In the case of a laterally placed abscess, the incision is made on the lateral side of the swelling The layers of the abdominal wall are divided until the peritoneum is reached With the finger the extraperitoneal tissues are separated from the peritoneum until the abscess is opened. A drainage tube is inserted If the path is tortuous, a Penrose drain is best

Appendix Abscess.—*See* p 234
Pelvic Abscess.—*See* p. 239
Abscess connected with Diverticulitis.—*See* p 232.
Subdiaphragmatic Abscess.—*See* p 342.

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CHAPTER XXI

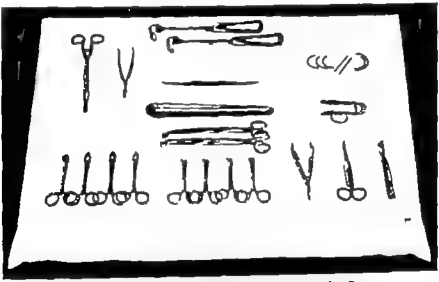
ACUTE APPENDICITIS

The earlier the operation the lower the mortality (J B Murphy)

When a patient is seen during the first 48 or 50 hours of an attack of acute appendicitis no question arises as to the best treatment; it is agreed universally that the appendix should be removed without delay In these circumstances appendicectomy is the most satisfactory operation of abdominal surgery

APPENDICECTOMY DURING THE FIRST FORTY EIGHT HOURS OF AN ATTACK OF APPENDICITIS

Instrumentarium.—The instruments required for the operation about to be described are shown in *Fig* 281 To reduce the number of instruments to the minimum compatible with efficiency makes for an orderly technique.



Sponge-holding forceps — Forceps for inverting the stump — Morrant Baker forceps — London Hospital retractors — Watson Cheyne dissector — Sargent depressor — Moynihan tetractips — Towel-holding clips — Needles — Author modification of Pruty's needle-holder — Jean dissecting forceps — Mayo scissors — Bard-Parker knife

Fig 281 —Instruments for appendicectomy with the exception of hæmostats, which are on separate table

The Incision.—*The gridiron incision* (p. 139) made over McBurney's point is the best one for the removal of an acutely inflamed appendix. If the method that has been described for enlarging the incision in necessary cases is followed, the sole objection to the gridiron incision—namely limitation of space—fades into insignificance It is well established that the gridiron incision is associated with the lowest mortality (Abel and Allen).

The paramedian incision For the designed removal of an acutely inflamed appendix a paramedian incision is far less suitable than the foregoing The appendix is often comparatively inaccessible from this approach By employing an incision so near the middle line it is possible to contaminate the medial portion of the peritoneum in cases where the infection was strictly localized Coils of intestine cannot be packed off so readily as in the gridiron incision.

However the paramedian incision is valuable when the diagnosis is in doubt particularly in a female when disease of the adnexa[1] cannot be excluded

Technique—We will assume that the abdomen has been opened by the gridiron incision Place a retractor under the medial side of the peritoneal incision and lift up the abdominal wall (*Fig* 282) This allows one to peer into the peritoneal cavity and to see the state of affairs before anything is disturbed. It is often possible to see the cæcum and occasionally the appendix also

Obtaining a Specimen of Peritoneal Exudate—Whenever possible a specimen of purulent peritoneal fluid should be collected for culture and sensitivity of the organisms present to antibiotics. To send a swab that has been in contact with the fluid to the bacteriologist for this purpose is not a fraction of the value of a fluid specimen in a stoppered test tube From the point of view of the surgeon, who would wish to examine more closely the character of the fluid as well as that of the bacteriologist it should be looked upon as a necessity to have a sterile test ended fountain-pen filler in readiness at every urgent laparotomy

If pus or purulent fluid wells up and a mechanical sucker is available it is used freely at this stage and whenever purulent fluid enters the field. Pack a portion of a roll of gauze under the medial side of the peritoneum and reapply the retractor over this before attempting to deliver the cæcum. It should be needless to emphasize that nothing must enter the peritoneal cavity without having a hæmostat attached. Pick up the cæcum between finger and thumb and draw it outwards and upwards. When the cæcum is difficult to

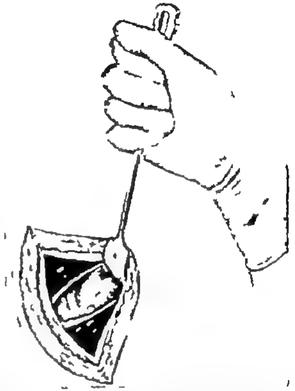


Fig. 282.—Appendicectomy Before attempting any intraperitoneal manipulation a retractor is placed under the medial side of the wound, and the abdominal wall is lifted up. The surgeon then peers inside before anything has been disturbed.

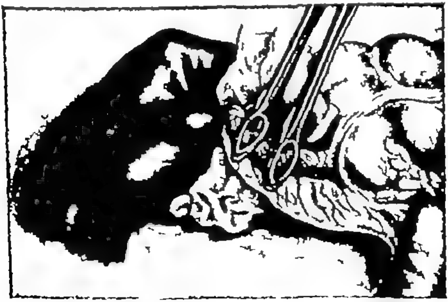


Fig. 283.—Appendicectomy The cæcum is held by an assistant Morrant Baker' forceps has encircled the appendix, and the meso-appendix is displayed

[1] A pelvic examination under the anæsthetic often helps to elucidate this problem.

grasp Denis Browne's forceps, used with a very light touch, without engaging the ratchet, are sometimes of distinct value but the fingers are the best, and if the beginner cannot get a hold of the cæcum it usually means that either the patient is straining under the anæsthetic or the incision is too small. Once a portion of the cæcum has been drawn out of the wound, it should be grasped between the finger and the thumb holding a moistened abdominal pack. *Using the pack, the cæcum is withdrawn fully and usually the appendix comes into view* The right index finger may be inserted into the wound to aid the gentle delivery of the appendix under vision, but only under vision Once the appendix has been delivered the cæcum is given to the assistant to hold. He should be instructed to take a good grip and hold the slippery structure with an abdominal pack (*Fig* 283)

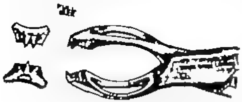


Fig 284 —Morrant Baker's forceps.

Morrant Baker's forceps (*Fig* 284) are applied around the appendix in such a way as to encircle the organ and yet not damage it (*Fig* 285). Clipping then cutting, section by section the meso-appendix is severed, until the base of the organ is reached. A long hæmostat is applied to the base of the appendix. It is released, and applied again a few millimetres more distally Around the crushed portion a ligature is applied, tied, and its ends cut short. *A purse-string suture is inserted to encircle the caput cæci about half an inch (12 mm.) from the appendix.* This stitch passes through the muscular coat,

Fig 285 — Appendicectomy All is in readiness for the insertion of the purse-string suture after which the appendix is removed by cutting across its base between the ligature and the hæmostat.

Inset shows Morrant Baker's forceps in use grasping the appendix without crushing it Lane's forceps with one tooth cannot be employed satisfactorily for this purpose when traction is applied the meso-appendix is torn by the single tooth.

particularly at the longitudinal bands. The purse-string having been inserted it is momentarily left untied while the appendix is severed between the hæmostat and the ligature (*Fig* 283) to employ a diathermy needle for this purpose renders the cut surfaces virtually sterile *The appendix, hæmostat, and Morrant Baker forceps are now free in the left hand, and if it has been employed, the scalpel is in the right.* All these are cast into a special dish because they are contaminated. The free ends of the purse-string are held moderately taut while the stump is invaginated with small non toothed dissecting forceps (*Fig* 286). The purse-string having been tied, the cut ends are left long and

grasped in a hæmostat. Attention is directed to the ligaturing of the meso-appendix. For this purpose always use transfixion sutures (*Fig* 287) which are safer than a simple ligature. I have seen at necropsy a hæmoperitoneum resulting from a slipped ligature on the meso-appendix. The transfixed ligature cannot slip. Finally in selected instances the long ends of the ligature which has been applied to the meso-appendix and the ends of the purse-string may be knotted (*Fig* 288) thus obliterating any cut edge of peritoneum. This step is only attempted when there is absolutely no tension between the structures involved

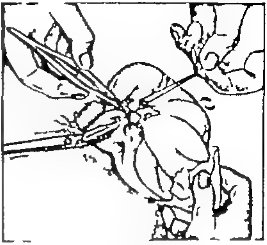


Fig 286.—Appendicectomy Inverting the stump of the appendix.

On Hooking out the Appendix —An experienced surgeon can and does, sometimes put in a finger and hook out the appendix. This is all very well for one who from experience can estimate the mobility of the organ in relation to the length of the incision. With much practice it is possible at a glance and a touch to recognize the flexibility or friability of a particular appendix. To the beginner hooking out the organ is fraught with danger The most dangerous appendix to attempt to hook out is one situated in the pelvis. Sir Frederick Treves in his well-known sketch, "The Idol with the Hands of Clay depicts graphically the fatal termination of an operation for appendicectomy by a sudden hæmorrhage. It is possible that the external iliac artery was hooked up for this artery may feel very like the continuation of a pelvic appendix (*Fig* 289). The safest method of delivering the organ is by gentle

Fig 287 —Appendicectomy Ligaturing the meso-appendix. Often several hæmostats re pplied in dividing this structure.

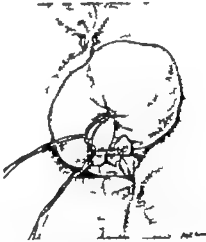


Fig 288 —Appendicectomy Knotting together the ligature which has been pplied to the meso-appendix and the long ends of the purse-string This is only done in exceptional cases where there is no tension between the two points.

traction of the cæcum. The finger may be used to ease the appendix through the abdominal wall, but this is not what is understood by hooking If the appendix does not come out kindly it means that more room is required.

It is far better to abstain from hooking altogether To enlarge the incision to see exactly what one is doing to dissect gently and pack away extraneous viscera, apply Morrant Baker s forceps in the manner described, and by these means to strive to lift the appendix intact on to the surface renders hooking unnecessary

Overcoming some Difficulties.—

The Cæcum cannot be Found.—This means that either the cæcum has not descended fully or that malrotation of the intestine (see p. 471) is present An extension of the incision in an upward direction is required.

The Appendix cannot be Found.—Make certain that it is the cæcum that has been delivered. The transverse colon is recognized at once because of the attachment of the greater omentum. Having made sure that it is the cæcum, trace one of the tæniæ coli

Fig. 199.—An inflamed appendix lying over the brim of the pelvis is often in intimate contact with the common iliac vessels.

downwards; this must lead to the base of the appendix. Another help is to retract the terminal ileal fat-pad[1] (P. Thorek). This pad, as its name implies, is a flap rather like a large appendix epiploica attached to the anterior surface of the last half inch or so of the ileum (*Fig.* 200). If this pad is seized (preferably with a Babcock's forceps) and retracted by the assistant to the left, the inferior ileocæcal recess is displayed, and often therein lies the base of the appendix. If still in trouble enlarge the wound, and after locating the ileocæcal valve (the appendix must be near this structure) palpate the back or under surface of the cæcum, for the appendix may be buried in the cæcal wall. If the patient has not had a previous abdominal operation, the only remaining possibility is that the organ has become inverted or intussuscepted (see p. 487). The umbilicated extremity of the cæcum should make this rare occurrence obvious.

The Appendix has Sloughed off.—Except on occasions so rare that they are unlikely to be encountered more than once in a surgical lifetime, the meso-appendix anchors the organ in the field of operation. Once only I found that the bulk of the appendix was missing. After dealing with the appendix stump the incision was enlarged, and a free appendix was retrieved from the pelvis without much difficulty.

Has all the Appendix been Removed?—The distal end of the appendix is dome-like and rarely, if ever, is there a perforation exactly on the convexity of the dome. If the tip of the organ has not been removed with the rest of the appendix, a probe passed along the lumen of the excised portion will demonstrate if a part is missing. Never leave behind

[1] Called by H. A. Kelly in his monumental work *Appendicitis* the jejunal-cæcal fold.

a piece of detached appendix the blood-supply has been cut off and consequently gangrene and liquefaction of the infected fragment is almost certain to follow The proximal end of the appendix, when buried in the cæcal wall, has been overlooked many times (*Fig* 291).

The Appendix lies buried Retrocæcally—In order to gain an unobstructed view of the peritoneal cul-de-sac to the right of the cæcum it is often necessary to enlarge the wound. Instruct the assistant to retract the cæcum to the left Once the reflection of the peritoneum on the lateral aspect of the cæcum is in view make the hockey-stick-shaped incision in the

Fig. 290.—A well-developed terminal ileal fat pad (x) in an obese subject (*After Howard A Kelly*)

Fig 291 —Showing how the proximal end of the appendix may be buried in the cæcal wall, and the cuff method of ensuring total appendicectomy (*After A Edmunds.*)

Fig. 292.—Incision in the posterior layer of the peritoneum to display a buried retrocæcal appendix. The usual distribution of the appendicular artery is also depicted. (*After G A Merris.*)

parietal peritoneum shown in *Fig* 202. After a little blunt dissection in the retroperitoneal space the cæcum can be retracted still further to the left, rendered far more mobile and rotated, the combined effect of which results in bringing the greater portion of a previously hidden appendix into full view

Fig 203.—Colour photograph of an actual case where slitting up the appendix was of inestimable assistance A concretion (broken in removal, and situated on the right of the swab) occupied the yellow area on the left, which is the base of the appendix. The inflamed mucosa is contrasted with the uninflamed mucosa. When inspected from without, the organ appeared perfectly normal.

Is the Appendix sufficiently Diseased to have Caused the Symptoms?—Having removed the appendix, pass the organ, wrapped in a swab, to some competent person in the theatre. Often the anæsthetist will undertake the examination of the specimen. The organ should be slit up from end to end with scissors no other method is efficient. If the appendix was the cause of the symptoms, assuredly it will be more inflamed on the inside than on the outside (*Fig* 203). When on macroscopical examination the mucous membrane proves to be normal and the occasion warrants it, search elsewhere for an intraperitoneal lesion.

The Appendix is clothed with Adherent Greater Omentum (*Fig* 204) —Make every effort not to disturb adherent omentum performing its constabulary duties, for so often within lies a gangrenous or even a perforated appendix. Usually the greater omentum should be divided between hæmostats at a convenient distance from the appendix, and then appendicectomy conducted as atraumatically as possible To excise an inflamed appendix replete in an omental overcoat is an occasion for congratulation.

Fig. 204 —After the appendix, together with an appropriat portion of omentum, had been excised, without detaching the latter the specimen revealed that the distal half-inch of the appendix was completely gangrenous.

The Appendix is Gangrenous near its Junction with the Cæcum.—Above all things be alive to the possibility of a sudden gush of liquid fæces from the cæcum. Should this calamity occur—and it has often done so—the patient's life is endangered, although provided the peritoneal cavity has been well packed off on the medial side and a mechanical sucker is available with antibiotic therapy the prognosis is less gloomy than formerly There is no golden rule for its prevention, but a surgeon aware of the possibility is far more likely to avoid it than one who is not. In exceptional cases, when the cæcum is ballooned, it is good judgement to deflate the cæcum in the manner described on p 444 before proceeding with the appendicectomy

The insertion of a preliminary (i.e., before appendicectomy is attempted) mattress suture into indubitably *healthy cæcal wall at an appropriate* distance from the junction of the appendix with the cæcum traversing if necessary the base of the meso-appendix, is a certain method of being forearmed (Lahey) This does not necessarily imply that the mattress suture is to be employed for purposes of invagination when the appendix has been removed and its stump has been closed satisfactorily When the appendix is gangrenous right up to its junction with the cæcum, the only reliable method of closing

the stump is by two sutures transfixing the cæcal wall. These must be inserted before the appendix is amputated (*Fig* 295).

The Caput Cæci is Infiltrated and Œdematous—In such circumstances it is unwise to attempt to insert a purse-string suture. It should be realized that invagination of the appendix stump is not essential. Indeed, a few surgeons state that it should never be

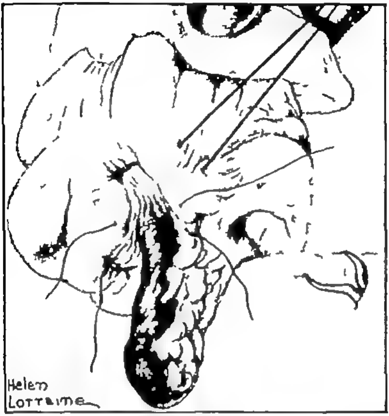


Fig 295—Gangrene of the cæco-appendicular junction. Methods of guarding against a fæcal deluge (*see text*)

employed.[1] When it is considered desirable to embed the appendicular stump in the presence of cæcal œdema, a good alternative to the purse-string suture is shown in *Fig* 296.

The Meso-appendix is Gangrenous and cuts out—This is not uncommon, and is a trying complication, especially in the obese. If a ligature will not hold, a stitch applied directly beneath a spurting vessel may stop the bleeding. On the other hand the artery is liable to retract and become hidden from view, in which case the ileal fat pad should be raised and the bleeding artery sought behind the ileum. The artery to the appendix takes a retrocæcal course, as also does the accessory appendicular artery (*Fig* 297).

Persistent Oozing—A swab moistened with a little snake-venom and left in situ for about thirty seconds at a time will often stop considerable oozing. A thin layer of oxycel will quell most oozing. Recourse may have to be made to packing the area for forty-eight hours. The necessity for this step is a great rarity, and it should not be resorted to unless the circumstances are most exceptional.

The Appendix is lying against the General Mesentery, and the Inflammatory Process has implicated the Latter—Usually the appendix can be dissected uneventfully from the mesentery. It is highly important to observe the ileum in the immediate neighbourhood of the affected portion of mesentery. If the intestine is discoloured from interference with the blood-supply, it is usually wise to resect the affected segment, as the following experience testifies.

[1] It is alleged that a "pus pocket" occurs under the tightened purse-string, and this is responsible for numerous complications, including that extremely rare condition, hæmorrhage into the bowel following appendicectomy. In view of the hundreds of thousands of appendix stumps which have been invaginated, it is obvious that this hypothesis does not warrant serious consideration.

In one case (of forty-eight hours duration) I found that, after the appendix had been separated, the mesentery of the last inch of ileum was bleeding seriously. Attempts to stop the hæmorrhage by ligature were only successful after several ligatures had cut out. When the bleeding was quelled finally it was noticed that the last two inches (5 cm.) of ileum were blue: the blood-supply had been interfered with seriously. This segment was therefore resected and ileocæcostomy performed. Recovery followed.

Fig. 298.—An alternative method to the purse-string suture. Three or four interrupted sutures are placed as shown. All are inserted before they are tied. The middle ones are the last to be tied.

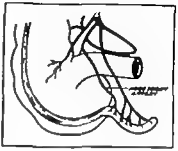


Fig. 297.—In nearly 80 per cent of cases there is an accessory appendicular artery, a branch of the posterior cæcal. (*After Seshachalam.*)

In a second example that occurred some years later there was no hæmorrhage, but two inches of ileum were œdematous and somewhat blue, evidently from thrombosis of the mesenteric veins in the neighbourhood. After hesitation, I decided not to resect. Ten days later the condition of the patient became critical rather suddenly: fæces poured from the wound. The small intestine had necrosed in this area, and he died in a few hours. I regretted that I had taken the conservative course.

Retrograde Appendicectomy.—

Indication.—When the base of the appendix is more accessible than the distal part of the organ. Retrograde appendicectomy is useful particularly in retrocæcal appendicitis when the extremity of the appendix is embedded in the cæcal wall or attached to retroperitoneal structures, yet the base of the organ is comparatively free (*Fig.* 298).

Technique.—The base of the appendix is inspected, and a Morrant Baker's forceps is applied a little distance from the cæco-appendicular junction in such a way that the appendix lies within its lumen. A little blunt dissection may have to be done before this step is possible. Gentle traction is then applied to Baker's forceps, and the interval between the appendix and the cæcal wall becomes apparent. The probe end of a Watson Cheyne's dissector is passed (through the meso-appendix) under the appendix, and two hæmostats are applied to the appendix close to one another (*Fig.* 299). The appendix is divided between them. If a scalpel (as opposed to diathermy) is used for this purpose it is discarded, for it is infected.

As far as the cæcum and the severed base of the appendix are concerned, the procedure is straightforward. With the hæmostat still grasping the appendicular stump a purse-string suture is inserted in the usual manner. *Only after this has been done* is the appendicular stump ligated: the hæmostat grasping the stump is then removed and discarded. After cutting off the fragment of crushed tissue that was held in the jaws of the forceps, the base of the appendix is buried by the purse-string suture.

The appendix is now excised in the following manner. By gentle traction on the hæmostat that grasps the freed base of the organ, aided by blunt dissection, the ill-defined meso-appendix becomes sufficiently demonstrable to clip and cut (*Fig.* 300), clip and cut, until the whole appendix is removed.

Ligatures having been applied the bed in which the appendix lay may be obliterated by a running suture. It is in this type of case that the last step is often particularly satisfactory

In selected cases retrograde appendicectomy is an excellent measure It renders easy what otherwise might prove an extremely difficult operation. But it must not be abused *It is necessary to have the whole course of the appendix under vision before the operation is commenced*, otherwise the terminal portion of a gangrenous organ is in danger of being overlooked

Drainage.—Drainage of the peritoneal cavity is absolutely necessary when an appreciable amount of frankly purulent fluid is present. In other instances, particularly when the fluid is in the immediate vicinity of the cæcum this is mopped or better still, extracted with a suction apparatus, and layers of the wound are closed with the exception of a corrugated rubber drain in the subcutaneous space. In very early cases only when the infection is limited to within the appendix and the hæmostasis is all that can be desired, is subcutaneous drainage omitted

Intraperitoneal drainage is *not* usually necessary —

1 In unperforated appendicitis, however evil the organ may look cases where there is a considerable purulent peritoneal exudate are excepted.

2. In cases where the appendix breaks or bursts during removal.

3. In recent perforation with a local serous or sero-purulent exudate. (By recent perforation is meant that there was no pre-operative distension or considerable acceleration in the pulse-rate)

Is there an Appreciable Amount of Pus or Purulent Fluid in the Pelvis?—This is, perhaps, the major problem before closing without intraperitoneal drainage. With experience the question seldom arises, for it is answered soon after the abdomen has been opened. The amount and the nature of the fluid that escapes when the peritoneum has been incised, the appearance of the interior when one peers into the peritoneal cavity before disturbing the viscera, the position of the appendix, the pre-operative rectal examination, and the pulse-rate are all factors which are taken into consideration.

Fig 206 —Gangrenous retrocæcal appendix attached to the lower pole of the kidney An indication for retrograde appendicectomy

In cases of real doubt a small swab on a holder is passed down into the pelvis through the incision, withdrawn, and examined by sight and smell. This diagnostic swab will tell if a suprapubic drain is needed. The method should not be employed promiscuously There is a danger of spreading infection from the right iliac fossa into the pelvis. The need for the diagnostic swab is only likely to arise when the appendix is pelvic, or purulent fluid is seen to well up from the pelvis. Provided it is employed only when there is a definite need, and not to be quite certain the method is more than justified.

Where to Insert the Drainage Tube—A suprapubic drainage tube through a special stab incision above the pubes is a life-saving measure in diffuse and pelvic peritonitis.

It is never necessary to put a drainage *tube* through the original appendix incision except when deliberately draining an appendix abscess. The most pernicious practice of all is to pass a long tube through the original incision into the pelvis. In this instance the tube takes a very oblique course that is in itself enough to condemn the method but in addition pressure necrosis of the external iliac artery by the tube is a possible complication, by no means unknown when this method was practised extensively

When the retrocæcal space needs draining it is best to avoid a stab drain in the flank, for the thick muscular layers of the abdominal wall in this situation are rather prone to cellulitis. Drainage by means of a Penrose wick drain (*see* Fig. 243, p. 190) is particularly valuable in this instance.

Fig. 299.—*Retrograde appendicectomy.* The base of the appendix has been isolated with the probe end of a Watson Cheyne's dissector. Two hæmostats are applied in the manner shown, and the appendix is divided between them on to the dissector which can also be seen.

Leaving the Wound unsutured.—Referring to the gridiron incision. If, as is frequently unavoidable, the layers of the incision become contaminated during the operation, there is much to be gained by leaving muscular layers unsutured. Some surgeons leave the skin completely unsutured as well. By using this method infection and cellulitis of the abdominal wall occur but rarely (Deaver).

Drainage v. No Drainage.—In reviewing fatalities in cases of *unperforated* gangrenous appendicitis treated by appendicectomy without drainage, Fowler and Bollinger found that it was unfortunate that drainage had not been employed in five instances. In four of these death was due to peritonitis, and one to intestinal obstruction secondary to the local inflammatory process. In the case of *perforated* appendicitis these authors found that, in spite of full antibiotic therapy the incidence of post-operative complications following appendicectomy without peritoneal drainage was 39·0 per cent, compared with 13·9 per cent in those drained. Seeing that drainage is undertaken in the more seriously contaminated cases, it must be admitted that supplementary peritoneal drainage is most rewarding.

WHERE THE DIAGNOSIS OF APPENDICITIS IS IN ERROR

It is not intended here to dwell upon the various conditions that may be and have been, mistaken for appendicitis, but to indicate briefly how to proceed when the abdomen has been opened by a gridiron incision and an intraperitoneal lesion other than appendicitis is found.

Peritonitis is manifest but the appendix though obviously inflamed is not perforated. Remove the appendix and detail someone in the theatre to slit up the organ. If the appendix is the cause of the peritonitis, its mucosa will assuredly be more inflamed than its peritoneal surface.

From the quantity and the quality of the fluid which escapes when the peritoneum is opened perforated duodenal ulcer is probable. If considered necessary guided by two fingers within

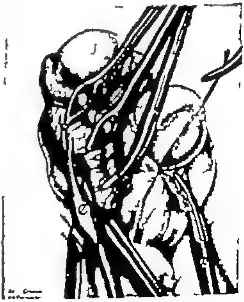


Fig. 300.—Retrograde appendicectomy. The base of the appendix has been divided and the appendicular stump invaginated. The appendix is in the course of being removed from the base to the tip.

the abdomen, insert a suprapubic drain (which incidentally will enable you to get a good sample of the fluid for your inspection and for culture) Close the appendix incision and open the upper abdomen.

Perforated diverticulitis is probable After having examined the last two feet of ileum for a Meckel's diverticulum (this step can be omitted if there is a lead to the site of the diverticulitis), close the incision and reopen the abdomen on the left side. (*See* COLONIC DIVERTICULITIS, p. 231)

Also refer to table of peritoneal exudates (p. 106) which in the contingency under consideration is of definite assistance.

Intussusception of the appendix (*see* p 467)

POST-OPERATIVE TREATMENT IN ACUTE APPENDICITIS

Antibiotic Therapy.—Full details are given on p 202.

General After-treatment.—Omnopon, ⅓ gr., is given and repeated six hourly for three doses, if required.

In cases with peritonitis, gastric aspiration is employed for at least 24 hours, or until flatus is passed For a like period continuous intravenous dextrose-saline is given. In the presence of meteorism these measures of ensuring gastro-intestinal rest should be continued until the bowels have opened. In exceptional cases, when a low hæmoglobin justifies it, blood transfusion is given.

Bowels.—The management of the bowels is of more than ordinary importance. Purgatives and peristaltic stimulants are banned absolutely Enemata should only be given (and not before the fourth day) if ordered in writing Liquid paraffin is the only laxative allowed, and that should not be commenced until at least the fifth post-operative day again it must not be given as a routine The only methods permitted without special order are the passage of a flatus tube and the insertion of a glycerol suppository If an enema becomes necessary it must be stated that it is to be a low pressure enema given under the sister's or charge-nurse's supervision.

COMPLICATIONS FOLLOWING APPENDICECTOMY FOR ACUTE APPENDICITIS

Internal Fæcal Fistula.—This should be suspected when the patient suddenly develops signs of diffuse peritonitis between the fourth and seventh days after appendicectomy A large enema or a purgation is frequently the determining cause, and the appendicular stump bursts open. Once the condition has developed the only possible treatment is immediate operation and conversion of the internal fistula into an external one. The sheet anchors are then antibiotic treatment and supportive fluid therapy This complication, which is not as rare as may be thought, is of course extremely serious, but with prompt operative treatment and antibiotic therapy is not hopeless.

Wound Infection occurs frequently especially in cases where the appendix was perforated. The administration of antibiotics does not appear to offer any protection against this complication (Wolff and Hindman) As emphasized already non-closure of the grid iron incision (peritoneum excepted) at least prevents spreading cellulitis of the abdominal wall.

Residual Abscess.—In about 5 per cent of cases of suppurative appendicitis treated by operation, a further operation for a residual abscess is required (Cutler) Except in the case of a pelvic abscess or a subdiaphragmatic abscess, when such a localized intraperitoneal collection of pus is suspected, operation should be delayed until a mass can be palpated, until it is discrete, and, if possible, until it is so adherent to the abdominal wall that it can be approached without opening the general peritoneal cavity In a few instances residual abscesses resolve. In all cases it is advised to mark the extent of the abscess on the skin and to make frequent clinical examinations. When necessary drainage should be carried out by the most direct route possible. Usually it is unwise to prise open the original incision.

Acute Intestinal Obstruction.—Appendicectomy for perforated appendicitis is the commonest cause of post-operative intestinal obstruction (*see* p. 413). Other complications that occur from time to time are :—

1 Paralytic ileus (*see* p 462)
2. External fæcal fistula (*see* p. 320).
3. Subdiaphragmatic abscess (*see* p. 312)

4 Pylephlebitis (see p. 340).
5. Femoral and iliac phlebothrombosis (see p. 923).
6 Pulmonary embolus (see p. 930 and Chapter XCIII).
7 Post-operative pulmonary complications (see p. 144)
8 Melæna after appendicectomy (see p. 293).

APPENDICITIS IN PREGNANCY

Ignore the pregnancy Appendicitis is a serious lesion, and as such should be treated on its merits. (Cuthbert Lockyer)

Since both pregnancy and appendicitis are more common during early adult life, the finding of a higher incidence of appendicitis in primagravida and secundipara who are *less than 30 years of age is consistent.* Pregnancy with its shift of the vermiform appendix from the pelvis to an abdominal organ, favours peritonitis the nearer to term, the greater the danger even in cases of appendicitis without perforation. As a consequence the overall mortality *in spite of antibiotic therapy is in the neighbourhood of 20 per cent.* The unwillingness to perform early operation because of doubt in diagnosis is the main reason for having still to categorize appendicitis as a very grave complication of pregnancy

A fact which must be continually before the surgeon is that acute appendicitis is a supremely important complication of pregnancy and if only the diagnosis can be established within forty-eight hours from the onset appendicectomy can be undertaken safely The difficulty is to establish the diagnosis. As pregnancy advances the pain becomes higher and more lateral. Pyelonephritis of pregnancy which is usually right-sided, is the condition most frequently confounded with appendicitis. When it is of paramount importance to exclude pyelonephritis, excretory urography and the microscopical examination of specimens of urine obtained from the right ureter by cystoscopy and catheterization will sometimes help to settle a very important and urgent question, especially in early pregnancy but it should be known that pyuria and appendicitis can coexist (see p. 575).

The symptoms of right-sided ectopic gestation, twisted ovarian cyst, salpingitis, and necrobiosis of a uterine fibroid are often similar to those of appendicitis. In doubtful cases it is best to perform early laparotomy

Operation.—When the intra-abdominal manipulations can be reduced to a minimum the pregnancy is not necessarily interfered with. When operation has to be undertaken during the first three months of pregnancy abortion occurs in about 20 per cent of cases. After the third month the liability to abort becomes increasingly less. If peritonitis has set in, abortion or premature delivery is the rule even in advanced pregnancy Once I removed a gangrenous perforated appendix at the twenty fourth hour in a woman six months pregnant, and she miscarried shortly afterwards, but recovered.

The fact that the patient is pregnant makes no difference in selecting suitable cases for the Ochsner-Sherren treatment (see p. 232) A pertinent example is as follows —

The patient was a woman of 28, four months pregnant with a large peri-appendicular phlegmon. She was first seen on the seventh day of the attack of appendicitis, and the *pulse was 112.* On the next day the pulse was 104 and after that it remained between 73 and 80. Slowly the mass resolved completely Appendicectomy was performed two months after delivery

When *acute appendicitis complicates pregnancy* near term, and the patient has reduced pelvic measurements, the lives of the mother and the unborn child are at stake The correct course is first to undertake the Cæsarean section, and then to proceed with appendicectomy, preferably through a gridiron incision. With antibiotic therapy the prognosis after this dual operation has greatly improved.

ACUTE APPENDICITIS IN INFANTS AND YOUNG CHILDREN

The mortality of acute appendicitis in children under 5 is still higher than that of the general mortality One of the reasons for this is that perforation occurs early and often, and the greater omentum, being comparatively short and poorly developed is unable to perform its customary constabulary duties. Nevertheless, the chief reason for this high mortality is difficulty in diagnosis. The four earliest signs of acute appendicitis in infancy are pyrexia abdominal pain, vomiting, and local tenderness. Any of *these may predominate, any may* be absent, and any may be associated with another symptom which is uncommon in older patients, to wit, diarrhœa (Bunton)

Temperature and Pulse.—In a baby very little constitutional upset is sufficient to produce a considerable rise in temperature. In over 50 per cent of cases the temperature is more than 101 F (33 3° C.). A steady rise in the pulse-rate is of great diagnostic significance. The administration of antibiotics tends to mask these signs.

Pain usually comes in attacks, causing screaming or crying with the knees drawn up. It is highly important to make repeated examinations as necessary for it is useless to palpate the abdomen when the child is crying Stealthy abdominal palpation with the hand under the bed-clothes is usually the best.

Thoracic respiration comes on early and must be looked for carefully

Vomiting.—In many cases the axiom "pain precedes vomiting is reversed. Occasionally both are absent.

Diarrhœa occurs frequently and when present is a cardinal sign. The stools are very loose and often contain mucus. This is due to the proximity of an inflamed pelvic appendix to the upper rectum. How easy it is to attribute the diarrhœa to enteritis, and even send the child to a fever hospital ! Rectal examination is particularly valuable in childhood.

Auscultation reveals a nearly normal amount of peristalsis, whereas in enteritis it amounts to a hubbub.

Treatment.—Fifty years ago Dr Ochsner of Chicago (of the Ochsner-Sherren régime) insisted that the delayed treatment should not be employed in children. This does not imply that adequate time should not be taken in correcting dehydration and rendering the patient in the best condition possible for the operation. Ladd whose experience in this field is unrivalled, conforms with this view

In relatively small peri appendicular phlegmons occurring in older children, the delayed method can be safely employed, but one certainly should be particularly on the alert for danger signals.

Full general anæsthesia with gas, oxygen and ether is the most satisfactory when operating upon children. In cases where the appendix is probably unperforated the gridiron incision can be employed with perfect satisfaction. In the very young, when complications are anticipated, an incision over the middle of the right rectus, splitting its fibres, will be found efficient. Moreover if drainage is required, the lower end of this incision is an admirable avenue for the exit of a drainage tube.

Antibiotic Therapy.—Patients under 5 years of age are given 500 mg of aureomycin initially and then 250 mg every four hours, until improvement sets in, after which 250 mg is given every six hours until the temperature is normal and the patient appears clinically well for five days. Older children are given the same dosage, except that 1 G is given initially If the patient can take fluids by mouth the drug is given in syrup If gastric aspiration is being employed, the aureomycin is injected down the tube and suction stopped for an hour (Blackburn and Drake).

Fig. 301.—The frequency of perforation in patients over 60 years of age (*Wolff and Hindmarsh's statistics.*)

ACUTE APPENDICITIS IN THE AGED

Gangrene and perforation (*Fig* 301) occur much more frequently in elderly patients probably because vascular occlusion occurs more readily on account of arteriosclerosis. In the evening of life, patients not infrequently harbour a gangrenous appendix within the abdomen with such paucity of symptoms and signs that the true diagnosis or its severity is not appreciated until too late. Rigors occur relatively frequently in acute appendicitis in the aged (20·3 per cent as opposed to 8·4 per cent in controls) They are of ominous import, usually signifying the presence of spreading peritonitis. As Lewin emphasizes, by the time surgical opinion is sought abdominal distension is present, and often intestinal obstruction is considered to be the most probable cause of the symptoms. Such cases require early laparotomy

The post-operative complication rate in the older age group is three times that in the control group. Among the less obvious reasons for this is that a high proportion of cases, owing to uncertainty of diagnosis, are submitted to paramedian laparotomy and are denied the undoubted benefit of a gridiron incision.

It is commonly stated that the Ochsner-Sherren delayed treatment should not be employed in elderly subjects. I have found no objection to employing this treatment in this age group in cases where there is a localized palpable mass. Resolution occurs somewhat less frequently but the burden of years does not appear materially to affect the issue.

LEFT-SIDED APPENDICITIS

More than 100 cases of appendicitis occurring in patients with transposition of the viscera have been reported. The main interest in these cases lies in the fact that, despite the position of the appendix on the left, in a proportion of cases the pain is situated on the right side. The explanation of this paradoxical phenomenon is unknown. A likely reason for the appendix being on the left side is non-rotation of the mid-gut (*see* p. 471).

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CHAPTER XXII

LATE ACUTE APPENDICITIS

ACUTE APPENDICITIS WITH GRAVE DIFFUSE PERITONITIS

Meditation before operating is no less important than proper operative technique. (H. J Kohlmann.)

WHETHER the delayed method is going to be employed or not, there is not a shadow of a doubt that in order to get the patient into the best possible condition it is better to delay the operation for several hours (*see* p. 202) Usually as a result of fluid therapy gastric aspiration, and antibiotics, indications of some improvement become manifest. We are now faced with a problem requiring a high degree of surgical judgement.

It will be recalled that Ochsner first framed this method for cases of diffuse (spreading) peritonitis. There is plenty of evidence that some cases of this type respond favourably to the Ochsner-Sherren treatment. In this instance such treatment aims at aiding nature to transform the diffuse peritonitis into a localized infra umbilical or pelvic collection of pus that can be treated safely by simple drainage.

Experience teaches us that simple drainage without removal of the appendix *before localization of the peritonitis has occurred* rarely saves the patient's life. Indeed, in many instances it appears to hasten the end. On the other hand, in most cases the *expeditious* removal of the appendix, together with suprapubic drainage and possibly caecostomy (*Fig* 302) is, I believe, the best method of treating diffuse peritonitis due to a perforated appendix, but the operation must be expeditious and the anaesthesia as perfect as possible. Should the operation prove to be difficult, necessitating considerable intra abdominal manipulations, or if the attempt to remove the appendix has to be abandoned in favour of simple drainage death usually follows. In such circumstances one must be prepared to admit that the patient might have been saved by the delayed method.

Fig 302.—This patient was admitted in a moribund condition with diffuse peritonitis. Under local anaesthesia supplemented by a very small dose of thiopentone appendicectomy was performed, together with suprapubic drainage and caecostomy Photograph taken on the fourteenth day Aluminium paint is protecting the skin from excoriation. The faecal fistula healed spontaneously

In the light of the above remarks, before advising immediate operation, at least it is necessary for the surgeon to pause and ask himself a question. Is it likely that this appendix can be delivered without undue difficulty?

No one can answer this question with assurance, but one can say this much —*When the disease has been present for more than sixty hours, it is practically certain that the appendix will be matted to neighbouring structures*

Especially when the data before us signify that matting is present, we should meditate: even before the advent of the antibiotic era many contemporary and recently deceased master surgeons renowned for their manual dexterity subscribed to the teaching of Albert Ochsner in the United States and James Sherren in the United Kingdom Years of experience, doubtless bitter experience taught them that perseverance with the delayed method in the hope of localization of the infection offers the patient his best chance There are two notable exceptions to this rule —

1 *In childhood and early adolescence.* Early in life localization of a diffuse peritoneal infection does not occur often enough to warrant a trial of the delayed method[1] unless the circumstances are extenuating

[1] This does not imply that operation-on-diagnosis is indicated. Several hours of treatment designed to correct dehydration and to relieve gastric and intestinal distension is of cardinal importance.

2. *If there is good reason to believe that the diffuse peritonitis is due to the recent bursting of an appendix abscess.* Here simple drainage is a life-saving measure.

An endeavour has been made to show that there must be adequate reasons for adopting a particular method. If those reasons dictate delay *in operating*, then the surgeon must be courageous, for in this instance it requires more courage *not* to operate.

THE OCHSNER-SHERREN OR DELAYED TREATMENT OF APPENDICITIS

Indications.—The Ochsner Sherren treatment can be recommended in many cases of acute appendicitis of over fifty hours duration

The following exceptions are made, and early (in most cases immediate) operation is advised —

1 In the presence of hyperaesthesia. (Other things being equal the presence of hyperaesthesia indicates that the appendix is still unperforated.)

2 When there is uncertainty in diagnosis.

3. When there is obviously considerable peritonitis (*see* p. 231).

4. When a purgative has been ingested recently

5 In children especially those under the age of 8 years.

In order to practise the delayed treatment successfully the surgeon must be a reliable diagnostician. If intraperitoneal lesions normally requiring immediate operation cannot be excluded definitely it is wiser to operate.

Technique.—The delayed treatment of appendicitis *must* be carried out on the threshold of the operating theatre by the surgeon himself for at any moment operation may become imperative The responsibility for delaying operation rests entirely with the operating surgeon, and no other It is he who is going to perform the operation, and he is at liberty to choose the time that he will do it. In a highly civilized country it should be absolutely forbidden to attempt this treatment outside a surgical hospital or a correspondingly equipped nursing home, preferably with a staff acquainted with the principles of the method. On the other hand one can picture extenuating circumstances where, by reason of these circumstances, the risk of attempting this treatment would be less than attempting operation—for instance, in a small ship at sea.

Clinical Notes.—A careful history is recorded together with a diagram of the physical signs at the time of the first examination. Every effort is made not only to diagnose appendicitis irrefutably but also to diagnose the *position* of the appendix, whether it is retrocaecal, in the right iliac fossa, or pelvic. The patient is then placed in true Fowler's position (*see* p. 191 et seq).

Charts.—As a routine the pulse-rate is recorded every two hours in graphic form on a special chart. In cases where anxiety is felt as to the advisability of continuing the treatment, an hourly chart is employed. On several occasions, when the peritonitis has been widespread, I have had a half hourly chart prepared through the night. The temperature is relatively unimportant it is recorded every four hours. A special antibiotic chart and a fluid intake and output chart are strongly recommended.

Gastric Aspiration (intermittent or continuous) is carried out in all cases when vomiting has occurred, or the patient feels nauseated.

Diet—For the first 48 hours nothing at all is given by the mouth. Continuous intravenous dextrose-saline is administered At the end of 48 hours sips of water are allowed. As the intake by mouth is increased so the intake intravenously is decreased, and, as a general rule by the evening of the third day the intravenous fluid is discontinued altogether It is most desirable to explain to the patient that he is going to be starved—"in order to try to prevent the appendix bursting" is a phrase that can be understood by the patient and his relatives. On the fifth day if the pulse and temperature are satisfactory and the patient feels hungry feeding is commenced. Small feeds of proprietary milk preparations (e.g., Benger's food), alternating with a cup of meat extract, are given. On the sixth day custard and jelly are allowed. After that the diet is increased gradually

Drugs.—It should be noted particularly that morphine or its derivatives are not allowed

Antibiotic therapy: Penicillin 500,000 units and streptomycin 0·5 G are given intramuscularly 12 hourly

Bowels.—The bowels are left confined if they are not opened naturally. On the fourth day a small glycerol enema is given. No purgatives of any kind are administered until resolution is complete—that is, until the pulse and temperature have been normal for a week and pain and physical signs are absent. Then liquid paraffin 2 oz. (60 ml.) thrice daily is prescribed.

Pain as opposed to *tenderness* is complained of very seldom after the first night of the treatment. A hot water bottle may be given to the patient to apply to the abdomen but it is well to repeat, that as long as the inflamed appendix remains in situ drugs are forbidden, for they may mask those all important signs which foretell that the delayed treatment is not likely to succeed. Instructions are given for the nurse in charge to watch the patient carefully and report immediately (1) A rising pulse-rate (2) Vomiting (or copious dark gastric aspirate) (3) Pain (4) Diarrhœa or the passage of mucus in the stools (pelvic abscess).

A *rising pulse rate* in the early stages is the most reliable *single* sign that it is dangerous to proceed with the delayed method. If the pulse-rate has increased even ten points in the first four hours, operation is often indicated. One should not feel alarmed at a moderate rise in temperature. It quite often indicates that the patient is exhibiting a good reaction to the inflammatory process. It does not necessarily mean that a local abscess is developing though this, of course, may be the case, and will be revealed by the physical examination. A moderate rise of temperature with a pulse-rate in the eighties or nineties does not necessarily foretell failure of the delayed treatment.

Vomiting after the first few hours should always be regarded seriously and this by itself may be a sufficient indication to abandon delayed treatment. This statement refers to those comparatively favourable cases where there was no indication that gastric aspiration was necessary at the primary clinical examination.

Indications for abandoning Conservative Treatment.—A patient undergoing delayed treatment should not complain of *pain* as opposed to tenderness, after the first six hours of treatment. If he does there is usually something wrong and this is a strong indication for operation. In the few cases in which pain has been the determining factor in advising operation a large thick walled unperforated appendix had been found. The patient was experiencing appendicular colic.

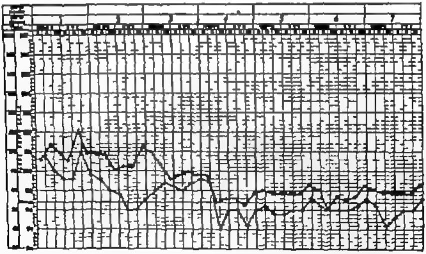

Fig. 303.—Chart, showing resolution of a case of appendicitis under Ochsner Sherren treatment.

After a large experience of the Ochsner-Sherren treatment I have nothing but praise for it. Several hundred cases have resolved uneventfully (*Fig* 303). As in surgical practice one always seems to get ill fortune in batches, it sometimes happens that several cases in a short period of time fail to resolve.

If the delayed treatment fails, and the patient has been starved for some days, the urine should be examined for acetone before giving the anæsthetic, but if the patient has been receiving dextrose-saline acetonuria is most unlikely.

In order that there should be no slackness in its application the dangers of this treatment have been emphasized—perhaps even over-emphasized. The method in itself is life-saving; the chief danger lies in its abuse. Surely this is true of most good things.

2. *If there is good reason to believe that the diffuse peritonitis is due to the recent bursting of an appendix abscess.* Here simple drainage is a life-saving measure

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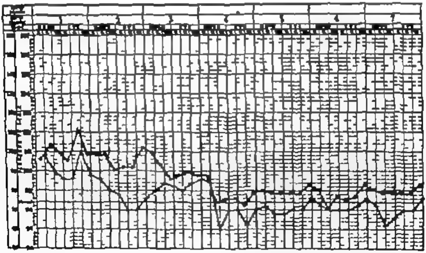

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In order that there should be no slackness in its application the dangers of this treatment have been emphasized—perhaps even over-emphasized. The method in itself is life-saving the chief danger lies in its abuse Surely this is true of most good things.

In order to strengthen the confidence of those who have not had the advantage of a thorough training in the method it can be stated with assurance —

1 Subdiaphragmatic abscess is almost unknown.

2. Pylephlebitis does not occur I have had a number of cases of pylephlebitis associated with acute appendicitis, but not once has it developed in a patient undergoing delayed treatment (*see* PYLEPHLEBITIS, p 340)

3. Intestinal obstruction is very much rarer than after immediate operation.

4. The treatment is not a hardship to the patient.

5 In the long run there is very little wastage of hospital beds. But what is this in *the matter of saving a useful life?*

In some quarters the Ochsner Sherren treatment is frowned upon, and especially in the face of criticism it often requires more skill and courage to undertake this treat ment than to operate. As McNeill Love says, "psychological reasons are a great deterrent to the adoption of expectant treatment. If a case treated on delayed lines ends fatally it is usually regarded as a tragedy and all concerned may have lingering doubts in their minds as to whether immediate operation would have saved the patient. On the other hand, if the appendix is immediately removed and the patient succumbs, the general impression is that because immediate operation was performed everything possible was done, and the fatality is accepted philosophically"

Eventual Appendicectomy—One of the most important duties in a case where the delayed treatment has proved successful is to ensure that the patient has his appendix removed in due course. Experience shows that in an average case an interval of two months is necessary for the products of inflammation to resolve completely Appendicectomy soon after clinical resolution is often a very difficult operation, and the patient, by reason of the starvation is ill prepared to stand it. If an interval of two months elapses between the time he is fit to be discharged and the operation, it will be found that the patient s general condition will have improved, and the local œdema, friability and increased vascularity so much in evidence soon after clinical resolution are absent consequently the operation proves comparatively easy It is remarkable how few adhesions are found.

Unfortunately a very real danger creeps in. The patient may fail to appear for his operation I found that more than 5 per cent of those who had successfully undergone the Ochsner-Sherren treatment failed to return. They were written to, and a proportion replied, with varying excuses, the principal being that they had not understood. The following is a good plan. As soon as it is evident that resolution can be expected confidently the patient is handed two cards to sign. On each is printed the following words :—

> I realize that I have just been tided over an attack of appendicitis. The surgeon considered that in my case it was safer to defer operation. I fully understand the danger of leaving the appendix, and I agree (1) To come into hospital on
> (2) To report at the hospital immediately if I have any symptoms before that date.
> *Signed*

One card the patient takes away The other is indexed and serves to remind the staff of the appointment, which, except in special cases, is made for a date two months after leaving This method has worked admirably and frees the surgeon of the responsibility of inadvertently omitting to explain the necessity for eventual operation.

PERI APPENDICULAR PHLEGMON

(syn. *The Appendix Mass*)

Well-founded criticism has been levelled at the term appendix abscess when it is used to denote a lump associated with an inflamed appendix during the comparatively early stages (three to five days) of the onset of an attack. It must be conceded that at this time the lump consists mainly of œdematous cæcum plastered with greater omentum and probably coils of œdematous small intestine; true, there may be a small quantity of pus around the appendix in the midst of this conglomerate medley but it is confusing and inaccurate to designate such a swelling as an abscess. Although favoured by many the term appendix mass is less descriptive than peri-appendicular phlegmon, which conjures up a picture of the true underlying pathology—a state of cellulitis rather than a collection of laudable pus—and it will help to segregate those cases of acute appendicitis above all others that are in dire need of the surgeon s clinical acumen and repeated watchful attention rather than his immediate operative skill.

On the other hand, when the time factor and non resolution make it almost certain that the lump in question is composed largely of pus, there should be no reluctance in designating the swelling as an appendix abscess.

The type of case *par excellence* for delayed treatment is when the patient gives a typical history of acute appendicitis of three or more days duration when the pulse-rate is not above 90 and when a localized mass can be palpated in the right iliac fossa.

Mapping out the Lump.—If it is to be a scientific gauge more attention than might be imagined must be given to the procedure. Secure an ordinary indelible pencil and take with you a glass containing a little water After moistening the tip of the pencil in the

Fig 304.—Marking out the periphery of the lump. This must be done accurately using deep index-finger pressure.

Fig 303.—Patient undergoing the Ochsner Sherren treatment for appendix abscess. The extent of the lump has been marked on the skin.

water try marking your own wrist. Ensure that the skin of the abdomen is not greasy for it may be that antiphlogistine or some other substance has been applied. Palpate the lump, with special reference to its periphery before starting the marking The best method of ascertaining the periphery is by deep index finger tip pressure (*Fig* 304) Little by little pressing then marking, the periphery is outlined (*Fig* 303). Explain to the patient the importance of the procedure, and should the lump be tender ask him to

bear the pain and, if possible not to contract his abdominal muscles. In all cases where there is a second practitioner in attendance (e.g., a house surgeon) ask him to confirm the accuracy of the outline and not to be afraid to differ Once the mark has been agreed upon, pencil on the date. Request the nursing staff to see that the marking is not washed off, and prescribe, if necessary not hot fomentations, but an electric heating pad (a hot water bottle, because of its weight and the possibility of bursting or leakage, is less desirable).

When overlying rigidity makes the exact outlining uncertain, and assuredly this will occur quite often, on no account should one lull oneself into completing a hypothetical periphery the uncertain zone is left uncompleted. This is *the* occasion for repeated examinations, and the diligent clinician may even find an opportunity to complete his handiwork while the patient sleeps.

Delayed Treatment.—The Ochsner Sherren treatment is carried out in exactly the same way as has just been described. Each day the outline on the skin is compared with the underlying lump A rectal examination must be performed at least every third day or more often if the mass has invaded the pelvis. Pelvic abscess is considered later in the chapter

It must again be emphasized that the delayed treatment must be carried out by the surgeon himself on the threshold of the operating theatre.

G P aged 11 whilst undergoing the Ochsner Sherren treatment for appendix abscess, appeared to be going on well, although the size of the abscess was not decreasing. On the fifth day he suddenly collapsed and showed signs of general peritonitis. Within fifteen minutes gas and oxygen was administered and drainage instituted both suprapubically and locally His condition was critical for several days, but he recovered, and six months later appendicectomy was performed uneventfully

This is a most exceptional complication it is indeed the only example of its kind that I have encountered but it illustrates forcibly that the Ochsner-Sherren treatment must be carried out on the threshold of the operating theatre.

Difficulties in Diagnosis.—Twice I have mistaken a ballooned cæcum, following on large-gut obstruction for an appendix abscess. In each case, because of vomiting, the patient was submitted to operation after twenty four hours of delayed treatment, and no harm resulted Twice twisted ovarian cysts were mistaken, and again pain and vomiting brought the cases to operation on the second day with recovery At least once I have not been able to make up my mind between an abscess connected with perforated colonic diverticulitis and appendix abscess, and I have waited, with fatal results. If perforated diverticulitis enters the clinical picture this is sufficient indication for early exploration.

In a number of instances where the lump has not decreased in size Crohn's disease (see p. 250), carcinoma of the cæcum, or actinomycosis has proved to be the underlying cause but this is not an error or a disadvantage; indeed it has everything to recommend it, for one has been enabled to become thoroughly familiar with the lump and to suspect one of the above conditions before embarking upon a difficult operation. Moreover the delay permits the oral administration of neomycin or sulphasuccidine in order to sterilize the contents of the bowel in preparation for possible resection.

The Case is responding Favourably.—Purposely the snares have been emphasized before dealing with the more usual course to be expected. The majority of these cases do exceptionally well under the delayed treatment. With starvation, rest, and antibiotic therapy the lump gradually gets smaller and smaller and finally disappears. When the time comes for the appendix to be removed one often marvels at the freedom from adhesions; perhaps there are a few dried up pieces of leathery substance stuck upon the appendix or the juxta-appendicular structures, but this is all that remains of what was once a periappendicular phlegmon giving rise to a lump say the size of a cricket ball. To those familiar with the delayed treatment such a phenomenon is commonplace.

In a few most exceptional instances the surgeon has been astonished to find that the appendix has disappeared. The most satisfying explanation is that an intussusception of the appendix was present, and that the inverted appendix, bereft of its blood-supply sloughed.

Abscess Formation.—If delayed treatment has been instituted those masses in the right iliac fossa that do require evacuation of pus will be frank abscesses, and the technique can be reduced to one of simplicity for the question of removing the appendix at the time of the evacuation of the pus never arises. This, no doubt, helps to account for the very small mortality in cases of appendix abscess treated on the above lines. We are spared the possibility of turning a localized infection into fatal spreading peritonitis,

a tragedy that I have witnessed more than once when I was attached to a surgeon who believed in early operation for all cases.

I have collected the notes of 90 consecutive cases of acute appendicitis with a localized mass treated by myself by the Ochsner Sherren method. In 69 instances the palpable mass slowly disappeared. In 21 cases the abscess did not resolve, and drainage was carried out. There was one death, and that was the fourth in the series. This occurred before I realized it was necessary to allow at least two months to elapse between resolution and appendicectomy

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3. Œdema of the subcutis—a rare occurrence which indicates that the abscess has already been left undrained too long

DRAINING AN APPENDIX ABSCESS SITUATED IN THE RIGHT ILIAC FOSSA

Technique.—The swelling is palpated under the anæsthetic. A point is chosen about the centre of the swelling, but rather nearer the lateral (*Fig* 306) than the medial aspect. A small incision is made small because it is naturally very prone to become infected and there will be less of it to break down.

Having traversed the subcutaneous tissues and displayed the external oblique the lump is again palpated by a finger in the wound, and an area well lateral to the centre of the swelling is chosen. The external oblique is divided in the direction of its fibres. The internal oblique is divided *across* its fibres. Two advantages are claimed for departing from our usual practice of splitting the muscle. First, an incision of 1½ in. (3·8 cm.) will be found to be adequate if the internal oblique is divided instead of being split secondly drainage is direct. There is no valve-like action of the criss-cross to interfere with the exit of pus and the re-insertion of a shorter tube.

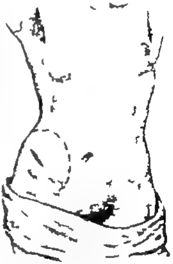

Fig. 306.—Incision suitable for draining an abscess in the right iliac fossa.

Retractors are inserted under the muscles and the peritoneum, which is often greatly thickened, is sought. The aim should be to open the abscess extraperitoneally " Cut through the abdominal muscles layer by layer You will find them very œdematous. If you can distinguish the peritoneum, strip it (laterally) with the finger " (Marmaduke Sheild.)

The index finger is passed into the wound and very very gently burrows laterally and posteriorly (*Fig* 307) In the case of a large abscess it is hardly a moment before the finger is felt to enter a cavity The finger is still kept in situ and acts as a bung to the flow of stinking pus until a tube can be passed into the abscess cavity The tube is fixed to the skin by a single stitch, which is often the only one necessary to approximate the wound about the tube. Pus now flows through the tube and may be collected in a receptacle. As the abscess cavity collapses, the flow becomes more and more blood-stained. This is not a cause for alarm. The abscess cavity is lined by granulation tissue which oozes freely

If inadvertently or by design the peritoneal cavity is opened, every care should be taken to avoid breaking adhesions unnecessarily especially on the medial side. The extremity of a length of gauze is packed gently into the *medial* part of the wound. " The effectiveness of gauze in protecting the general peritoneal cavity has often filled me with astonishment when I have seen *foul*, stinking pus pour from a large appendix abscess and beating against the barrier of gauze which I have placed to prevent it flowing into the peritoneum." (Barnard.) It should be noted that no matter whether the abscess

bear the pain and, if possible, not to contract his abdominal muscles. In all cases where there is a second practitioner in attendance (e.g., a house surgeon) ask him to confirm the accuracy of the outline, and not to be afraid to differ. Once the mark has been agreed upon, pencil on the date. Request the nursing staff to see that the marking is not washed off, and prescribe, if necessary, not hot fomentations, but an electric heating pad (a hot water bottle because of its weight and the possibility of bursting or leakage, is less desirable).

When overlying rigidity makes the exact outlining uncertain, and assuredly this will occur quite often, on no account should one lull oneself into completing a hypothetical periphery: *the uncertain zone is left uncompleted. This is the occasion for repeated* examinations, and the diligent clinician may even find an opportunity to complete his handiwork while the patient sleeps.

Delayed Treatment.—The Ochsner Sherren treatment is carried out in exactly the same way as has just been described. Each day the outline on the skin is compared with the underlying lump. A rectal examination must be performed at least every third day, or more often if the mass has invaded the pelvis. Pelvic abscess is considered later in the chapter.

It must again be emphasized that the delayed treatment must be carried out by the surgeon himself on the threshold of the operating theatre.

G. P., aged 11, whilst undergoing the Ochsner-Sherren treatment for appendix abscess, appeared to be going on well, although the size of the abscess was not decreasing. On the fifth day he suddenly collapsed and showed signs of general peritonitis. Within fifteen minutes gas and oxygen was administered and drainage instituted both suprapubically and locally. His condition was critical for several days, but he recovered, and six months later appendicectomy was performed uneventfully.

This is a most exceptional complication. It is indeed the only example of its kind that I have encountered, but it illustrates forcibly that the Ochsner Sherren treatment must be carried out on the threshold of the operating theatre.

Difficulties in Diagnosis.—Twice I have mistaken a ballooned cæcum, following on large-gut obstruction for an appendix abscess. In each case, because of vomiting, the patient was submitted to operation after twenty four hours of delayed treatment, and no harm resulted. Twice, twisted ovarian cysts were mistaken, and again pain and vomiting brought the cases to operation on the second day, with recovery. At least once I have not been able to make up my mind between an abscess connected with perforated colonic diverticulitis and appendix abscess, *and I have waited, with fatal results. If perforated* diverticulitis enters the clinical picture this is sufficient indication for early exploration.

In a number of instances where the lump has not decreased in size Crohn's disease (see p. 250), carcinoma of the cæcum, or actinomycosis has proved to be the underlying cause, but this is not an error or a disadvantage; indeed, it has everything to recommend it, for one has been enabled to become thoroughly familiar with the lump and to suspect one of the above conditions before embarking upon a difficult operation. Moreover the delay permits the oral administration of neomycin or sulphasuccidine in order to sterilize the contents of the bowel in preparation for possible resection.

The Case is responding Favourably.—Purposely the snares have been emphasized before dealing with the more usual course to be expected. The majority of these cases do exceptionally well under the delayed treatment. With starvation, rest, and antibiotic therapy the lump gradually gets smaller and smaller and finally disappears. When the time comes for the appendix to be removed one often marvels at the freedom from adhesions; perhaps there are a few dried-up pieces of leathery substance stuck upon the appendix or the juxta-appendicular structures, but this is all that remains of what was once a periappendicular phlegmon giving rise to a lump, say, the size of a cricket ball. To those familiar with the delayed treatment such a phenomenon is commonplace.

In a few most exceptional instances the surgeon has been astonished to find that the appendix has disappeared. The most satisfying explanation is that an intussusception of the appendix was present, and that the inverted appendix, bereft of its blood-supply sloughed.

Abscess Formation.—If delayed treatment has been instituted, those masses in the right iliac fossa that do require evacuation of pus will be frank abscesses, and the technique can be reduced to one of simplicity, for the question of removing the appendix at the time of the evacuation of the pus never arises. This, no doubt, helps to account for the very small mortality in cases of appendix abscess treated on the above lines. We are spared the possibility of turning a localized infection into fatal spreading peritonitis,

a tragedy that I have witnessed more than once when I was attached to a surgeon who believed in early operation for all cases.

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is approached extraperitoneally or intraperitoneally it is the finger and not an instrument, that is used to penetrate the wall of the abscess.

After the patient has been returned to bed and has regained consciousness, he is again placed in the sitting position and a pillow placed under his left loin in order to keep him on his right side and thus invoke the aid of gravity. After the first forty-eight hours the tube is turned and shortened only. Usually it is omitted altogether on the sixth day. There are seldom any complications if a frank abscess has been drained.

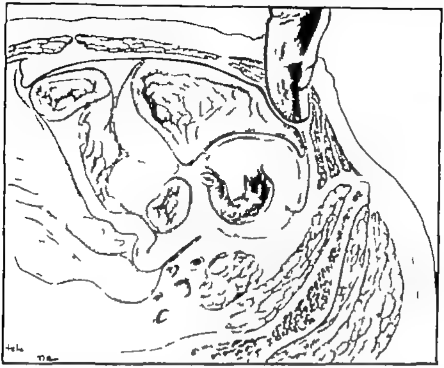

Fig. 307.—Opening an appendix abscess extraperitoneally. (*After A. Ochsner.*)

The patient should be given a card to sign bearing the agreement to return for appendicectomy (see p. 234). He should be examined at monthly intervals. It is most inadvisable to attempt the second operation (appendicectomy) until at least *four* months later, which may be extended to six months, unless of course symptoms develop in the meantime.

Dangers and Difficulties.—

1. One may have to burrow for some little distance before a retrocæcal abscess is opened. This burrowing must be done very gently. In certain cases it may be advisable to place a tube through a counter-incision in the flank, in which case the original incision is closed about a corrugated rubber drain.

2. Owing to some mischance, such as fatness of the abdominal wall masking physical signs, or undue anxiety on the part of the surgeon, cases occasionally come to operation where the abscess is resolving.[1] In such cases, on opening the peritoneum a mass as hard as a rock may be felt. If this lump has been present for some time and carcinoma is suspected, the incision must be enlarged, otherwise my advice in the case of a hard, fixed, rock-like mass is to leave it alone, sew up the abdominal wall with the least possible intra-abdominal disturbance, and return to masterly inactivity. In six instances where this has been done resolution has proceeded evenly in spite of the untimely incision. In three of these cases the abdomen was closed without drainage. In each of the six cases appendicectomy was undertaken successfully in six months' time. On no account tear through the indurated tissues with the finger in an endeavour to find central pus. One is almost certain to prise open the cæcum and an external fæcal fistula is but one of the grave complications that will ensue.

[1] In a few instances when the abdomen has been palpated under the anæsthetic a hard mass, hitherto unsuspected, has been found. Instead of opening the abdomen the patient has been returned to bed and treated by the Ochsner-Sherren method.

DRAINAGE OF A PELVIC ABSCESS PER RECTUM

Nature has taught us to drain these abscesses into the rectum (F T Paul.)

The pelvic abscess now under consideration is one that is seen in surgical as opposed to gynæcological practice and usually but not necessarily arises as a complication of acute appendicitis. As is well known, pus can accumulate in the pelvis without serious constitutional disturbance (*Fig* 308) It is therefore not surprising that these abscesses sometimes attain large proportions before being recognized. The most characteristic symptoms to which they give rise are diarrhœa and the passage of mucus. The latter is of cardinal diagnostic importance it is no exaggeration to say that the passage of mucus occurring for the first time in a patient who has, or has recently had, an attack of acute appendicitis is pathognomonic of pelvic abscess. Rectal examination reveals a bulging of the anterior rectal wall, which, when the abscess is ripe becomes softly cystic. It is inaccurate to say that it fluctuates, unless fluctuation can be elicited between it and the anterior abdominal wall. Fluctuation cannot be tested with one finger

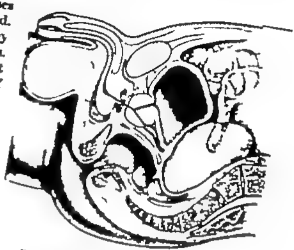

Fig 308.—Symptoms referred to the bladder—usually increased frequency some times retention, of urine—are to be expected in cases of pelvic abscess.

Left to nature a few of these abscesses burst into the rectum, after which the patient nearly always recovers. Deliberate opening into the rectum should be contemplated only when the swelling is quite soft. When the patient is considered to be *developing* a pelvic abscess, provided he is kept in Fowler's position and frequent (at least daily) rectal examinations are carried out, and the only disturbing feature is a hectic temperature it is good judgement to wait until the swelling is quite soft, when opening the abscess into the rectum should be contemplated. In such circumstances the operation proves one of the most satisfactory in surgery

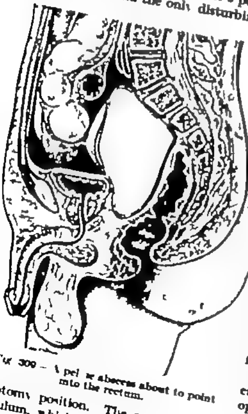

Fig 309 — A pelvic abscess about to point into the rectum.

Summarizing blind rectal drainage should be reserved for those cases where the history the free discharge of mucus, the cystic swelling centrally placed, and complete absence of abdominal rigidity make the diagnosis of a localized abscess pointing in the rectum (*Fig* 309) absolutely certain.

Doubtful Cases.—If there is the slightest doubt in the mind of the surgeon as to whether the swelling in question is an undeniable abscess—and it is sometimes difficult, particularly in post operative cases, to be quite certain—the patient should be placed on the Ochsner Sherren régime (*see* p. 232), and antibiotics administered. In a number of cases the pyrexia and diarrhœa will abate and no further treatment is required. Others will go on to undoubted pelvic abscess formation, and drainage becomes necessary

Technique.—The bladder must be completely empty therefore a catheter is passed on the operating table This step should never be omitted. The patient is placed in an exaggerated lithotomy position. The anal sphincter is dilated, and the small end of a Sims vaginal speculum, which answers the purpose admirably is introduced into the rectum (*Fig* 310). The passage of some mucus when the speculum has been inserted is very characteristic

and strengthens the diagnosis of a ripe pelvic abscess considerably Should the operator feel in doubt as to whether pus lies beneath the rectal wall he can introduce a large lumbar puncture needle guiding the point with the left forefinger If necessary an aspirating syringe can be attached after the stilette has been removed (*Fig* 311) but this is seldom necessary for the pus flows down the needle when the fore-finger presses the swelling A long hæmostat is the best instrument with which to penetrate the rectal wall. This is done not by a sudden jab, but by even pressure. As soon as the abscess is entered, pus streams down the speculum. A suitable rubber drainage tube is inserted into the abscess cavity

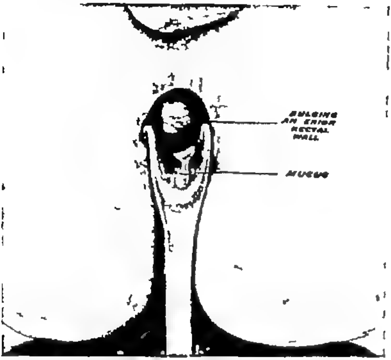

Fig 310.—All is in readiness for opening a pelvic abscess into the rectum.

Lee McGregor is most insistent that the tube should not be anchored to the perianal skin, as he has seen serious cellulitis follow this usual practice. It may therefore, be a better practice to endeavour to keep the tube in place with flexible adhesive plaster or to cut the tube short enough to rest intrarectally on the upper surface of the internal sphincter as advised by Barnard. After 3 or 4 days the tube can be removed.

Diarrhœa, which is usually present prior to operation, ceases once the abscess is opened. If possible, the bowels should remain confined until the tube is removed. The patient is nursed in Fowler's position for a week. *Fig* 312 shows the temperature chart of a case treated in this way I have used this method in a large number of cases, and never with regret.

In the case of an adult female, particularly a married woman, posterior colpotomy (Chapter XLIX) is a good alternative, perhaps even a better method than rectal drainage

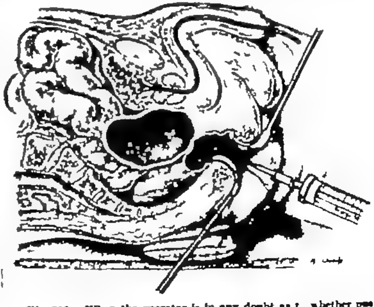

Fig 311 —When the operator is in any doubt as to whether pus lies immediately beneath the rectal wall, aspiration will confirm or dispel that doubt.

As is exemplified in the case that follows, a collection of pus in the pelvis sometimes gives rise to symptoms of intestinal obstruction.[1] When he is convinced that there is a ripe

[1] After the abscess has been drained usually these symptoms abate promptly

abscess in the rectovesical pouch, this feature should not deter the surgeon from carrying out *blind* rectal drainage. Of several relevant examples, the following is the most dramatic :—

I was called to the country to see a case of "intestinal obstruction". Beside the patient, who was a middle-aged, thin, hollow-eyed woman, there was a bowl of fæculent vomit, and she was adding to this with "mouthful" vomits. The pulse-rate was 120 and strong, and her abdomen was enormously distended. She said that she had been vomiting for four days, but had little pain. Her bowels had been open all the time; indeed, she had some diarrhœa. A week before the onset of the vomiting she had had an attack of "gastric influenza". A gastric aspiration tube was passed and 2 pints of fæculent matter were withdrawn. Continuous intravenous administration of dextrose-saline was then commenced.

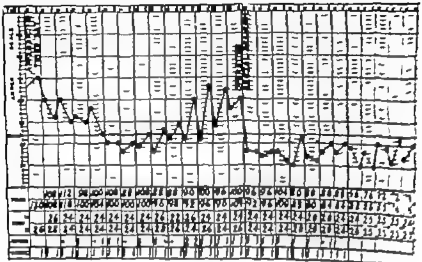

Fig. 512.—The temperature chart of a patient who developed a pelvic abscess which was drained per rectum.

The abdomen which, up to that time, had only been inspected, was palpated. The enormous distension had been much reduced and was now mainly confined to the lower abdomen, where a swelling could be felt in the hypogastrium. The patient said she had not passed urine all day. A sterile catheter was passed and a large bowlful of urine was withdrawn.

Re-examination of the abdomen, that by now was assuming a more normal contour, made it evident that there was still a swelling arising out of the pelvis.

With the patient in the lithotomy position, I inserted a finger into the rectum. There he found a tremendous bulging of the anterior rectal wall. In order to endeavour to elicit fluctuation, I exerted some pressure on the abdominal swelling with my left hand when to my astonishment the finger in the rectum passed through the mucosa and entered a cavern. As soon as I removed my finger the bed became filled with stinking pus, and the patient, who had not complained of pain, said she felt faint. After she had received about half a pint of dextrose-saline intravenously, her condition improved. By that time the doctor had arrived; she said she felt better and her abdomen had assumed almost normal dimensions. Never before or since have I seen such a change in the shape of an "acute abdomen" in the matter of an hour.

She recovered, and four months later came to London for appendicectomy.

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CHAPTER XXIII

ACUTE SALPINGITIS

It is better to make the mistake of opening the abdomen in a case of doubtful early pelvic inflammation than to risk death from hæmorrhage with ectopic pregnancy (W O Johnson.)

EMPHATICALLY in cases of acute salpingitis, it is far better not to open the abdomen as an urgent measure. Equally emphatically it is better to perform urgent laparotomy when one is not quite sure of the diagnosis. Throughout my career I have laboured the latter point, for I learnt my lesson early

The beautiful daughter of a pharmaceutical chemist, whose shop was not far from the hospital, was sent in late at night as a case of acute appendicitis. It fell to her lot to be admitted under me—then a particularly raw and youthful house surgeon of one week s standing In accordance with instructions, I summoned the Surgical Registrar to see the patient. He diagnosed acute salpingitis, and appropriate conservative treatment was instituted.

Although the charts showed that the patient s pulse and temperature were entirely satisfactory and although no vomiting had occurred, she continued to complain of pain, and in my opinion the tenderness increased. Consequently 48 hours later I telephoned my chief, who instructed me to ask the Surgical Registrar to re-examine her The Registrar referred to had gone on a short well-deserved holiday so it came about that his deputy (with less experience) examined the patient on this occasion. He reaffirmed the diagnosis of acute salpingitis and subscribed to the treatment that had been ordered.

I was most unhappy about the patient, for all the time I felt she had appendicitis. I should like to think that the reason for this uneasiness was clinical intuition, but a more probable explanation was that her father who had many years of experience of prescribing over the counter had on more than one occasion hinted that he was surprised to see that his daughter had not been operated upon. So passed the fourth, fifth, and sixth days. Her pulse remained steady in the 80 s and she continued to complain of pain and I continued to harass the deputy Surgical Registrar concerning her

In the late afternoon of the sixth day after I had done a round of the wards and had satisfied myself that there was no change in this particular patient's condition, I left the hospital for two hours. On my return the Hall Porter told me that I was wanted urgently I found the patient slightly cyanotic. Her pulse was thready and 140. Her skin was clammy and I well remember that she told me her pain had gone and she felt better with all speed I summoned the Surgical Registrar (the *original Registrar had returned that afternoon). He opened the abdomen within half an hour* Stinking pus poured out. The appendix was completely gangrenous. She died before daybreak.

Manifestly acute salpingitis is a condition in which all-important is the diagnosis. Indeed there is not an acute abdominal catastrophe where the words of *Howard Marsh* "Happy is he who has no serious consequences of his erroneous diagnosis to regret" ring more true. To be responsible for the exodus of a young woman through arriving at the unproven assumption that she has contracted venereal disease—which is often what the position amounts to—is a heavy burden. The penalties of opening the abdomen on an erroneous diagnosis of early acute appendicitis or a ruptured ectopic gestation (more accurately tubal abortion) and finding acute salpingitis are comparatively very light indeed there is always the redeeming feature that the vermiform appendix can be removed. Rightly this is a source of satisfaction to all concerned.

The reader must not run away with the idea that a look-and-see policy is advocated as a routine on the contrary the reader is urged to elaborate and perfect his pre-operative *diagnostic régime—to spend time and trouble in* examining and, if necessary re-examining the patient and to open the abdomen only *if* he is still not sure that acute appendicitis can be excluded.

Diagnosis.—Acute salpingitis arises most frequently in the first week after abortion or delivery or after menstruation often in a patient with an already established intra uterine infection Typical gonococcal salpingitis is now comparatively seldom encountered antibiotic therapy has lessened the incidence and has minimized the sequelæ Probably the most common cause of salpingitis is attempting to procure abortion and violent douching by the patient, whether pregnant or not. Tubal infection is usually

EXAMINATION OF THE FEMALE EXTERNAL GENITALIA FOR INFECTION

(After Greenslade)

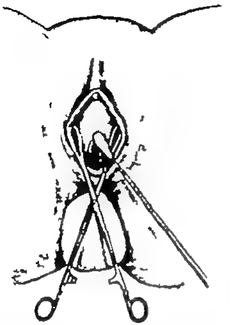

Fig 315.—The labia minora are separated by opening the jaws of sponge-holding forceps. The region of the urinary meatus is cleansed of secretion by means of a swab stick.

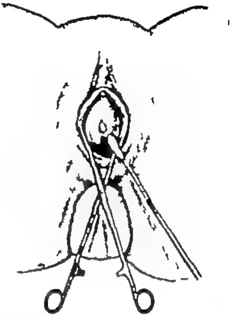

Fig 316.—Using a second pair of (closed) sponge-holding forceps the floor of the urethra is milked. Should a bead of pus appear at the meatus the opportunity to obtain a specimen is seized.

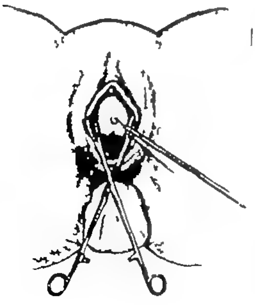

Fig 317.—Pus from the urethra is transferred (*a*) to a glass slide and (*b*) to an agar slope contained in a test tube each being labelled Urethra

Fig 318.—Once again the mouth of the urethra is wiped with wool on a probe The mouth of the urethra is compressed laterally with the second pair of sponge-holding forceps. Pus may be expressed from Skene tubules by this manœuvre. If so, specimens are secured and labelled Skene's tubules

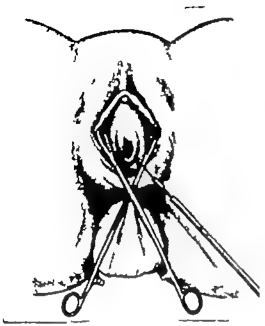

Fig 319.—The orifices of Bartholin's ducts are displayed. Pressure from above downwards and inwards with the forceps compresses these glands. If pus appears a specimen is secured on the platinum loop. These specimens are labelled "Bartholin." In any case the forceps are left in position while the speculum is passed.

Fig 320.—A bi-valved speculum is inserted. The mouth of the cervix is cleansed of secretion with the probe wool carrier. The platinum loop is passed into the cervical canal to collect specimens which are labelled "Cervix."

In a few instances the diagnosis of acute salpingitis is difficult in fewer still it is insuperably difficult. Most of the mistakes are due to a combination of three factors :—

a. Shyness on the part of the clinician.

b. Slip-shod methods in taking the history and examining the patient.

c. Sims position.

The first factor presents a real obstacle, especially in private practice. With a relative in the room one cannot go into the matter as one would wish to do.

The following method of procedure is the outcome of considerable experience. When it is carried out conscientiously it reduces the margin of avoidable error to vanishing point.

IN THE PATIENT'S HOUSE

The question of the differential diagnosis between acute appendicitis and a lesion of the adnexa arises. As a general rule, refrain from performing a pelvic examination. Suggest that such an examination is most necessary but as the patient must be transported to hospital for further observations and treatment, the internal examination is better postponed until after the journey. When the attending practitioner desires you to conduct a pelvic examination, perform a rectal examination, and unless something obvious is detected reserve judgment on the findings.

IN HOSPITAL

Go into the patient's menstrual and sexual history and the question of an intermenstrual discharge in more detail. If it seems desirable to speak with the patient alone, ask the nurse to fetch a second glove for the pelvic examination, or if that be present, to prepare a bowl of weak Dettol (chloroxylenol) solution.

If you are in doubt as to whether the patient has a vaginal discharge when the nurse returns examine the patient in the lithotomy position in a good light and satisfy yourself whether or not a discharge is present. If there is no discharge, inquire whether the patient has douched the vagina recently.

As a result of these planned devices the diagnosis may become clarified. In other instances one is still in doubt. If in doubt, it may be justifiable to order the patient to

be placed in high Fowler's position and to be watched carefully for two hours, but this course is not advised unless the circumstances are extenuating.

Provided the patient is not menstruating, there is everything to be gained and nothing to be lost by making a thorough vaginal examination in the operating theatre. Give instructions for the patient to be shaved and otherwise prepared for laparotomy. In appropriate cases let this preparation include pre-operative medication for a general anæsthetic, but make it clearly understood by everyone concerned that an anæsthetic and an operation may not be required. The patient's eyes should be blindfolded before she is transported to the operating theatre.

In the Operating Theatre.—The patient is placed in the lithotomy position. The armamentarium required for the examination is shown in *Fig.* 314.

The correct method of procedure to ascertain if a gonococcal or other infection of the lower urogenital tract is present, is so clearly depicted in *Figs.* 315–320 as to render further description unnecessary. When the parts have been visualized thus, and the specimens have been obtained, a most thorough bimanual vaginal examination can be carried out—a far more efficient examination than can be hoped for with the patient in bed.

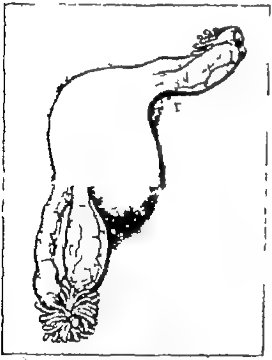

Fig. 331.—Acute purulent salpingitis, affecting mainly the right Fallopian tube.

As a result of the data obtained by the various expedients set forth the surgeon can now with a clear conscience make the important decision, whether (*a*) he will send the patient back to bed, or (*b*) he will open the abdomen forthwith.

Troublesome as it may be, it is only after an examination carried out in the above manner that it can be said that everything possible has been done to clarify the all-important differential diagnosis between acute pelvic appendicitis and acute salpingitis.

Is it :—

ACUTE PYELONEPHRITIS ?—*See* p. 378.

RUPTURED ECTOPIC GESTATION ?—*See* p. 531

PERITONITIS FOLLOWING ABORTION ?—*See* p. 210

TREATMENT OF ACUTE SALPINGITIS

High Fowler's position and other details outlined for the Ochsner Sherren treatment for appendicitis (p. 232) are instituted.

Gonococcal salpingitis in particular responds, usually within three days, to 500 000 units of penicillin bis die intramuscularly, or to aureomycin 1 G. t.d.s. orally. Excellent results have been obtained also with terramycin 1 G. daily.

THE ABDOMEN HAS BEEN OPENED AND ACUTE SALPINGITIS IS PRESENT

When the tubes are found to be inflamed and (often) pus is seen exuding from their ostia (*Fig.* 331), the reader is exhorted to leave them alone, aspirate any free pus in the peritoneal cavity, remove the appendix, and close the abdomen without drainage.

CLOSED PYOSALPINX

A closed pyosalpinx is found.[1] When a Fallopian tube is obviously distended as well as inflamed (occasionally both tubes are found in this condition) it is good surgery to remove it. After separating surrounding adhesions, the affected Fallopian tube can be displayed and removed satisfactorily by the following technique. The tube is grasped

[1] In pyosalpinx and tubo-ovarian abscess the confirmation of the diagnosis by culture of smears is not so conclusive as it is in acute primary salpingitis.

by two Morrant Baker's forceps in such a way that they do not crush or tear the friable appendage. By making a narrow "melon-slice" incision into the uterus around the origin of the Fallopian tube the tube can be detached from the uterus. The V-shaped wound

Fig 322.—Excision of a pyosalpinx.

in the uterus is under run by two or three sutures (*Fig* 322) which control hemorrhag and neatly approximate the edges of the wound. Clipping in hæmostats, then cutting the attachment of the tube to the broad ligament is severed. This method permits th separation of the fimbriated end of the tube from the ovary to which it is often amalgamated by an extension of the inflammatory process. In this way the ovary or a considerable portion of it can be conserved. The stumps of the broad ligament held in the hæmostats are securely ligated with transfixion sutures. Before closing the abdomen the raw surfaces are covered as is shown in *Fig* 323 and the greater omentum if available is drawn down and tucked about the operation area with a view to preventing coils of intestine becoming adherent to the inflamed ovary. Drainage is seldom necessary.

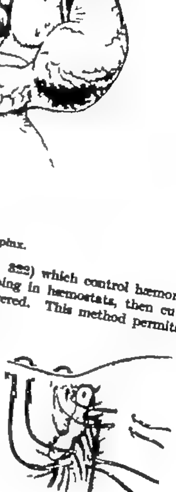

Fig 323.—A method of covering the raw surfaces after salpingectomy or salpingo-oöphorectomy. The round ligament is drawn over the raw surfaces by two mattress sutures placed as shown. (*After Wilfred Shaw.*)

TUBO-OVARIAN ABSCESS

In spite of the fact that the use of antibiotics has resulted in a decrease in the incidence and the severity of pelvic inflammation, cases of tubo-ovarian abscess[1] still occur quite frequently. The condition, which is met with in women between the ages of 16 and 46 years, gives rise to a tender swelling in the pelvis, accompanied by pyrexia. In about 50 per cent of cases the condition is bilateral.

Treatment.—With conservative treatment similar to that of the Ochsner-Sherren treatment of appendicitis which, with certain reservations, is the treatment of choice, the abscess often resolves. It must, however, be emphasized that some patients respond poorly if at all to delayed treatment, while others become worse, and an appreciable percentage die if operation is deferred too long. Even if there is a favourable response to conservative treatment a tubo-ovarian abscess often takes months of more or less continuous bed rest to resolve after which an operation to remove the infected focus is undertaken. Because of the danger of rupture of a tubo-ovarian abscess, as long as there is an inflammatory swelling present in the pelvis the patient should never be allowed to

[1] See footnote p. 216.

pass from direct observation, even if the temperature has remained normal for a week or more.

Failure of Conservative Measures.—Operation should be undertaken —

1 When the mass fails to become smaller or alternatively is getting larger

2. If pyrexia over 100° F (37 7° C.) continues for more than six days.

3. Recurrent attacks of pain occurring in a patient with known pelvic inflammation should be an indication for immediate operation, with the object of forestalling intra peritoneal rupture of the abscess.

When an urgent *operation is indicated, the essential step is to drain the abscess.* When the patient is extremely ill, or the abscess is large, posterior colpotomy[1] is the operation of choice provided the pus is accessible through the posterior fornix. In cases of doubt as to whether the abdomen should be opened or posterior colpotomy performed, diagnostic aspiration through the posterior fornix (*see* p 563) gives valuable information.

When the patient is in good condition, usually it is best to approach the abscess through the abdomen. If the affected appendage is found to be accessible, salpingo-oöphorectomy can be undertaken. This step is desirable for it gives better immediate and long term, results, whereas simple drainage is liable to be followed by a persistent sinus and/or incomplete resolution of the inflammatory mass, in which case, after a long conva lescence, excision of the uterus and both adnexæ is the only means of curing the patient.

Bilateral Tubo-ovarian Abscesses.—When bilateral tubo-ovarian abscesses are present, and fail to resolve there are two separate abscess cavities to be drained. These cavities often lie close beneath the abdominal wall, and are surrounded by adherent intestine and omentum. *Both cavities must be opened and drained. There should be no hesitation* in making two incisions in the abdominal wall, if it is considered that there will be less disturbance of the abdominal contents thereby

RUPTURE OF A TUBO-OVARIAN ABSCESS

A. G Miller states that although he still believes in conservative treatment of pelvic inflammation, his complacency in regard to possible rupture of inflammatory pelvic masses has been rudely shattered. Of 53 cases of rupture of a tubo-ovarian abscess collected by this author the rupture took place as follows —

Intraperitoneal	44	Cases
Intestinal	6	"
Intravesical	8	"

Intraperitoneal rupture is more likely to occur in a recent case where the abscess wall is thin and adhesions are fragile or lacking than in a long-standing case. Intra peritoneal rupture complicated 23 (3 per cent) of 751 cases of pelvic inflammation admitted to the Bellvue Hospital, New York (Lardaro). Of these, 17 were on the left side The relative frequency with which rupture occurs on the left side has been remarked upon by other observers. Lardaro s explanation is that it is due to raising of the intracolic pressure as a result of ingestion of a purgative or the administration of an enema. In a little under one-third of the cases the patient was admitted mortally ill, with general peritonitis due to a ruptured tubo-ovarian abscess that had been unrecognized or mis-diagnosed. In the remainder the rupture took place in hospital at various times from 1–23 days after admission. In an appreciable number of cases, rupture was precipitated by a bimanual examination.

Diagnosis.—When a tubo-ovarian abscess ruptures into the peritoneal cavity there is very severe pain in the lower abdomen, often followed by rigors, and less frequently by vomiting The general condition of the patient deteriorates steadily the degree of accompanying shock being proportional to the amount of pus liberated. In cases of rupture of a large abscess the pulse-rate may *quickly reach 160 beats per minute* the blood pressure becomes increasingly low In some cases the escape of pus through the rupture is comparatively slow and the only signs are those of gradual deterioration of the patient s general condition. Therefore in the absence of any systemic disease to account for the deterioration, rupture should be assumed and the patient operated upon without delay

[1] Posterior colpotomy will prevent rupture of the abscess into the abdominal cavity but after convalescence further operative treatment will be required to prevent a recurrence

Treatment.—Unless an urgent operation is performed, the patient's doom is sealed. In the absence of matched blood, dextran, followed by dextrose-saline should be given as soon as possible and the patient hurried to the operating theatre. When the blood-pressure does not quickly improve with intravenous fluid therapy several good results have been reported from adding noradrenaline to the intravenous fluid (see p. 77). The essential operative procedure is to drain the peritoneal cavity suprapubically. It is seldom that anything more should be attempted, for as a rule these patients are desperately ill. If operation is performed within six hours of rupture about 70 per cent of the patients recover.

The early administration of an antibiotic intravenously (see p. 202) is likely to improve these results.

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CHAPTER XXII

ACUTE REGIONAL ILEITIS AND ACUTE COLONIC DIVERTICULITIS

ACUTE REGIONAL ILEITIS

(Crohn's Disease)

In the first stage of the disease the symptoms closely resemble those of acute or subacute appendicitis with one notable exception, viz. almost invariably diarrhœa precedes the acute attack. Because early acute appendicitis cannot be eliminated rightly an emergency operation is performed. On opening the abdomen clear fluid escapes. The terminal

Fig 324.—Terminal ileitis (Crohn's disease). Note the enlarged lymph-nodes. *(After A B Jackson.)*

ileum, if examined, is found to be inflamed and much thickened; the mesenteric lymph-nodes of the area are considerably enlarged and fleshy (*Fig* 324). Usually these changes terminate abruptly at the ileocæcal valve. In a small percentage of cases the cæcum and the appendix itself take part in the granulomatous hypertrophy.

For practical purposes ileocæcal tuberculosis can be ruled out, because in the latter condition definite tubercles can be seen on the peritoneal surface of the intestine.

The one thing *not* to do in acute regional ileitis (and also in acute ileocæcal tuberculosis) is to perform appendicectomy, because so often in these conditions appendicectomy is followed by a fæcal fistula.[1]

If through some mischance, appendicectomy is commenced and then, on account of the comparative normality of the appendix, it is realized that the case is one of regional ileitis—a contingency which might reasonably arise—special precautions must be taken. The appendicular stump should be closed by a transfixion suture of well-tanned strong catgut. A purse-string suture should be omitted, for it will probably cut out. Indeed, it is best to avoid all attempts at invagination of the stump. A soft rubber drain should be inserted and retained for at least three days.

[1] For the same reason it is most unwise to excise a piece of the wall of the diseased intestine for biopsy.

On several occasions I have mistaken a mass in the right iliac fossa due to Crohn's disease for an appendix abscess or a carcinoma of the cæcum. Although termed a mistake, it is right that one of these relatively common conditions should receive diagnostic pride of place. The absence of pyrexia and a normal leucocyte count, greatly favours the diagnosis of a neoplasm, but the differential diagnosis between Crohn's disease and an appendix abscess may be insuperably difficult.

P. J. was a seedy looking man of 27 who gave a history of three days' abdominal pain consistent with acute appendicitis. A tender mass could be palpated in the right iliac fossa, and his temperature was 99° F. None of those in attendance questioned the diagnosis of localized appendicitis. Two days later, as the signs and symptoms were not settling—the temperature was 100°, and the pain had become more pronounced, and the lump was larger—operation was decided upon. There was massive induration of the cæcum and the appendix could not be found. After prising open the retrocæcal space without encountering pus, I wondered if I was dealing with a resolving appendix mass and committing the crime of breaking down Nature's barriers. Having regard to the clinical course of the disease, it was clear that resolution was not occurring. The complete normality of the small intestine seemed to rule out Crohn's disease; actinomycosis could not be ruled out. It was decided that the best course was to proceed with resection. Removal of the right half of the colon with ileotransverse colostomy was carried out with recovery. Histological examination of the specimen revealed that this was a case of Crohn's disease of the cæcum.

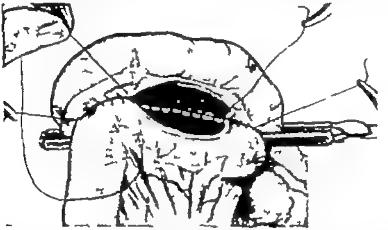

Fig. 325.—Ileotransverse colostomy in progress. Note that the ileum has been disconnected from the diseased area, both ends having been closed and invaginated.

Because recurrence follows in a high percentage of cases, resection of the affected segment is to be avoided in regional ileitis whenever possible. A much better course is to perform a disconnecting ileocolostomy between healthy ileum and the transverse colon (*Fig.* 325).

Acute Perforation of the Intestine in Regional Ileitis.—*See* p. 207

ACUTE COLONIC DIVERTICULITIS

With the increasing span of life, colonic diverticulitis is becoming more frequent. Colonic diverticulosis is acquired. The diverticula, which possess only two coats—an outer serous and an inner mucous—are caused by herniation of the mucosa through the muscle wall where it is pierced by an arteriole. Consequently the diverticula occur between the mesenteric and the two antimesenteric tæniæ (*Fig.* 326).

As a rule the appendices epiploicæ of a diverticula-bearing pelvic colon are luxuriant and contain fat of a bright yellow hue; occasionally a diverticulum passes into an appendix epiploica. While diverticulosis is distributed equally between the sexes, acute diverticulitis of the pelvic colon is at least two and a half times more common in men than in women.

Ninety-five per cent of colonic diverticula giving rise to symptoms are situated in the pelvic colon. The pathogenesis of acute diverticulitis is as follows: many of the diverticula contain inspissated fæcal matter. Should the mouth of a diverticulum become blocked by a fæcolith, inflammation of the obstructed diverticulum ensues. As a rule inflammation is confined to one diverticulum at a time; occasionally more than one become inflamed simultaneously.

The course of acute colonic diverticulitis can be summarized as follows —

Acute Colonic Diverticulitis:
- Resolution (sometimes with stenosis), often followed by chronicity and recurrent acute attacks.
- Subacute perforation with local abscess formation.
- Subacute perforation into a hollow viscus, notably the bladder
- Free perforation into the general peritoneal cavity
- Severe melæna.

Uncomplicated Acute Diverticulitis.—In typical cases the pain commences at the umbilicus and passes to the left iliac fossa, where the maximum tenderness is situated this makes the diagnosis from appendicitis simple. When the diagnosis can be made with assurance, conservative treatment similar to that of the delayed treatment of appendicitis should be employed nearly always resolution occurs. About a week after the patient is symptom free it is safe to give a barium enema. Assuming that this demonstrates the presence of diverticulosis of the pelvic colon, in a dangerous condition such as this, one should not be content to let matters slide. Rather one should take the current when it serves, and about three weeks after resolution has occurred advise an operation that will make the patient safe against future attacks and probable perforation, viz. resection of the affected portion of the intestine carried out after proper pre-operative preparation. On the other hand, for the poor risk patient a watching policy including a dietetic régime and the administration of antispasmodics and intestinal antiseptics, under the care of a physician, is advisable.

Acute diverticulitis presents itself in many guises, and examples, revealed only when the abdomen has been opened are bound to occur from time to time. For instance, when the inflamed diverticulum is situated in a loop of colon lying in the pelvis, tenderness is elicited mainly by a pelvic examination, and the differentiation between acute pelvic appendicitis and acute diverticulitis is not apparent until laparotomy has been performed

A taxi-driver stated that fourteen hours previously he had been seized with acute abdominal pain that had awakened him in the early morning His temperature was 99 F (37 2° C.) and his pulse normal. On abdominal examination the only physical sign was diffuse tenderness, most marked in the hypogastrium. Per rectum a hard lump could be felt in the rectovesical pouch. When I touched this the patient cried out in pain and said it felt like a red hot dagger being thrust into his navel. On opening the abdomen through a right paramedian incision the pelvic colon, which was turgid and bright red, was found in the rectovesical pouch and the nature of the tender lump was clear This portion of the colon could be readily delivered on to the surface through an incision in the left iliac fossa and a Paul Mikulicz operation was performed with recovery

More usually the mesocolon is short In these circumstances a Paul-Mikulicz resection (see p. 896) is impossible Therefore, as a rule, when acute diverticulitis is displayed at operation the correct procedure is as follows In order to wall off the area and prevent fistula formation with other hollow organs, the greater omentum is wrapped around the inflamed pelvic colon, and the abdomen is closed. Antibiotic therapy and a low-residue diet is given.

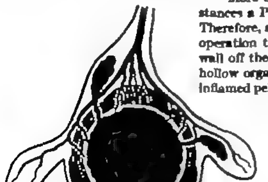

Fig 326.—Usual sites of diverticulation of the colon (*After Hamilton Drummond.*)

Localized Peridiverticular Abscess is a common complication of acute diverticulitis. When an inflamed diverticulum situated within the mesocolon (see *Fig* 326) bursts, the pus will be confined, at any rate for some time, between the layers of the mesocolon. In these circumstances the mesocolon becomes greatly thickened the bowel becomes angulated and the œdema resulting from pressure on the lymphatics and blood vessels is liable to result in partial intestinal obstruction.

On the other hand slow perforation of a diverticulum not thus confined gives rise to a peridiverticular abscess walled in by greater omentum and coils of small intestine Sometimes a tender mass can be palpated in the left iliac fossa (*Fig* 327); at others it i obscured by overlying rigidity

Delayed Treatment.—For a localized peridiverticular abscess delayed treatment consisting of absolute rest to the bowel, parenteral feeding, continuous gastric suction, and antibiotic therapy can be recommended with every confidence except in the following circumstances:—

1. If the patient has recently ingested a powerful purgative.
2. If on rectal or vaginal examination an indurated mass can be felt invading the rectovesical pouch as well as the left iliac fossa. It is difficult to estimate the size of such an abscess.

Fig. 327.—Abscess of the abdominal wall connected with a perforated diverticulum of the pelvic colon. A colocutaneous fæcal fistula followed incision of the abscess.

Just as in the case of the Ochsner-Sherren treatment of an appendix abscess, signs that foretell failure of the delayed treatment are:—

1. A rising pulse-rate or failure of an elevated pulse-rate to fall.
2. A hectic temperature.
3. Failure of the pain to abate, or recurrence of pain.
4. An increase in the size of the lump.

All the above are indications that operation should be undertaken without delay.

Operation for Peridiverticular Abscess.—The bladder must be emptied by a catheter on the operating table. Under the anæsthetic the periphery of the mass can be defined accurately. An oblique incision centred over the mass is made in the left iliac fossa, severing the fibres of the internal oblique instead of splitting them. This gives direct access. The abscess may be situated on the medial or the lateral aspect of the colon; seldom is it on both sides. Therefore, before opening the peritoneum it is a good practice to peel the peritoneum off the muscles laterally. Should this open the abscess, all that is necessary is to insert a drainage tube and make a suitable stab incision to accommodate it. More often the peritoneum must be opened over the centre of the incision. Gentle separation of adhesions with the finger soon enters a stinking abscess, unless it is confined between the leaves of the mesocolon. In the latter instance if fluctuation can be elicited, a closed hæmostat is thrust into the swelling and its jaws are opened. If fluctuation cannot be elicited and there is merely much thickening (and shortening) of the mesocolon, Lenhart and Flemming advise mobilizing the pelvic colon (which prevents intestinal obstruction by angulation) and placing a cofferdam drain (see Chapter XCIX) on the medial side.

For an abscess situated on the medial side of the colon invading the pelvis, Lenhart and Flemming also recommend cofferdam drainage.

A Colocutaneous Fistula is a usual sequel of drainage of a peridiverticular abscess (*Fig.* 327); such was the train of events in 24 out of 26 peridiverticular abscesses drained

by Mayo. It has long been the accepted practice in patients with a cutaneous or sigmoido-vesical fistula to perform transverse colostomy to completely divide the colon, and then wait 6 or even 12 months before attempting to resect the sigmoid. Since the introduction of antibiotic agents there is abundant evidence that in the absence of signs of intestinal obstruction, resection can be undertaken without this preliminary colostomy after a somewhat longer convalescence than is recommended in the case of uncomplicated diverticulitis. In old and enfeebled patients, when resection is contra indicated, a colo-cutaneous fistula is some guarantee against the development of further abscesses (Harold Edwards)

Fig 328.—Pneumoperitoneum in a case of perforated diverticulum of the sigmoid. (*C. C. Guy and C. ? Werelius.*)

Acute Free Perforation of an inflamed colonic diverticulum is not as rare as many seem to believe. Free perforation is responsible for the great majority of deaths in this disease, and one-quarter of the patients have no premonitory symptoms of diverticulitis. The radiological findings of pneumoperitoneum (*Fig* 328) suggest a perforated peptic ulcer although it should be recognized that gas beneath the diaphragm is to be expected in all free perforations of the large intestine.

While the operating theatre is being got in readiness, the patient is placed in Fowler's position, and continuous intravenous saline is administered. It is assumed that the diagnosis of diffuse peritonitis is evident, but, as is often the case, diverticulitis as the primary focus can only be suspected. Having suspected a perforated diverticulum of the pelvic colon as a cause of the peritonitis, it should be realized that spreading peritonitis following perforated colonic diverticulitis is one of the most lethal of the intra-abdominal catastrophes, consequently operation must be carried out with as little delay as possible

There is a Palpable Lump.—Examination under the anæsthetic may reveal a lump in the left iliac fossa that could not be felt before because of muscular rigidity (*Fig* 329). Should this be the case we are fortunate, for an appropriate incision over the mass will minimize intra-abdominal manipulations. In such circumstances I think it best to make a gridiron incision directly over the mass, and instead of splitting the fibres of the internal oblique to sever them.

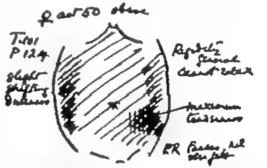

Fig. 329.—Physical signs recorded in the case of a woman of 80 with diffuse peritonitis. Under the anæsthetic a mass could be palpated in the left iliac fossa.

If, on an erroneous diagnosis of perforated peptic ulcer an upper abdominal incision has been made, foul-smelling gas escapes, and an indurated pelvic colon suggesting perforated diverticulitis is felt, the upper abdominal incision should be covered securely *pro tem* (transverse colostomy may have to be performed through it later) and the abdomen re-opened over the lesion by the incision recommended above

Methods of dealing with a Perforated Colonic Diverticulum.—

1. If it is possible to exteriorize the lesion (*Fig* 330) this is the safest of all measures. Failing this —

2. When possible the perforation should be closed and the defect reinforced by suturing an appendix epiploica over it.

3. In some cases the perforation is so large and the surrounding tissue so friable that suture is impossible. In these circumstances undoubtedly the course most likely to preserve the life of the patient is to resect the segment bearing the perforation close the distal end of the colon, tie a Paul's tube into the proximal end, and bring it out of the upper part of the wound, keeping it above skin level by passing a spigot through its mesocolon. In favourable cases the restoration of continuity can be carried out at a later date

4 Unfortunately in a number of instances when the peritoneum is opened, the perforation cannot be found readily There is a small quantity of stinking pus in a confusing mass of adhesions—proof that the peritonitis was secondary to bursting of a localized abscess. In some instances it is not possible to determine whether the indurated mass is the result of an inflammatory or a neoplastic process.

The best method of dealing with this perplexing situation is (a) Perform suprapubic drainage (b) Drain locally through the incision which is closed about the drain (c) After changing gloves perform transverse colostomy (*see* p 447)

Suprapubic drainage of the rectovesical pouch must be carried out in all cases of perforated diverticulitis. If the upper abdomen was opened in error it is closed as a last

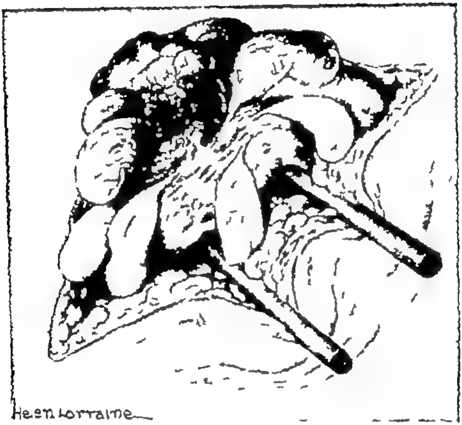

Fig 220 —Exteriorization of the segment containing the perforation. Note that two spigots are employed.

step. Gloves are changed, and as far as possible instruments that were used for the lower abdominal incision are avoided.

Severe Melaena, or more usually the passage of bright red blood has only recently been recognized as one of the *major* complications of colonic diverticulitis. Profuse hæmorrhage is due to ulceration of a relatively large artery within the walls of the diverticulum (*see Fig* 214). In the majority of cases the bleeding can be controlled by conservative measures, giving complete rest to the bowel, and by blood transfusion. In a few cases partial colectomy must be undertaken as an emergency Should this be necessary the bowel is excised in the manner described in this chapter It is most unwise to attempt to restore the continuity of an incompletely prepared colon of a patient in a parlous condition.

Acute Intestinal Obstruction complicating Chronic Diverticulitis.—*See* p. 232 and Chapter XXXIX.

Acute Diverticulitis of the Right Half of the Colon.—In 2 per cent of cases the inflamed diverticulum (it is often solitary) is situated in the cæcum or the ascending colon Usually the first intimation of its presence is perforation into the general peritoneal cavity Unlike diverticulitis of the pelvic colon, *diverticulitis of the cæcum and ascending colon usually* occurs in women under 40 years of age The condition is impossible to differentiate from acute appendicitis with diffuse peritonitis, and it is on this diagnosis that the abdomen

is opened. The vermiform appendix being unperforated a search elsewhere displays gas and fluid fæces issuing from the perforation. In some cases the perforation is situated on an easily recognized diverticulum in which case the pouch is excised and its base is invaginated. More often the perforation is found in the midst of an indurated mass that cannot be differentiated from a carcinoma. Provided the condition of the patient is excellent right colectomy with restoration of the continuity of the intestine by lateral ileotransverse colostomy (*see* p. 251) or by the Maylard-Sonnenberg technique (*see* p. 454) can be undertaken. If the peritonitis is advanced resection should not be attempted. The right colon is mobilized as necessary (*see* p. 440), and that part of it containing the perforation is exteriorized, a spigot being passed through the mesocolon in order to keep the bowel above skin level. When the patient is fit to withstand it, resection is carried out.

In all cases suprapubic drainage of the peritoneal cavity is essential.

Acute diverticulitis occurring in any portion of the colon other than the pelvic colon is comparatively favourable as regards mobilization. For instance, in a case of perforation of the transverse colon associated with an abscess of the abdominal wall in the region of the umbilicus, I excised the walls of the abscess cavity without opening it, and delivered the attached transverse colon. The Paul Mikulicz procedure was accomplished without difficulty and the result was pleasing.

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CHAPTER XXI

SOME OTHER CONDITIONS SIMULATING ACUTE APPENDICITIS

RENAL COLIC

Woe betide a patient with gangrenous appendicitis who passes blood in the urine! Until it is better known that an inflamed appendix lying in juxtaposition to the ureter (*Fig* 331) can give rise to ureteritis that causes hæmaturia, lives will be lost. When blood is found in the urine, almost invariably the practitioner rules out appendicitis, and not

Fig 331 —In cases of ureteritis secondary to appendicitis the appendix is nearly always retrocæcal. In this case the inflamed terminal portion of the appendix is adherent to the ureter

infrequently the consultant aids and abets him in treating the patient for "pyelitis" In no less than 80 per cent of cases falling into this group, the inflamed appendix occupies a retrocæcal position.

Directly connected with this outstanding example of misleading symptomatology is the anatomical variation where an inflamed appendix is resting upon or becomes attached to, the urinary bladder (*Fig* 332). It will be readily appreciated that in such circumstances the symptoms produced are wont to be predominantly urinary although in this instance hæmaturia is usually late and rare So it comes about that numbers of unfortunate individuals suffering from acute appendicitis presenting symptoms which direct attention to the urinary organs are denied the benefits of early appendicectomy

is opened. The vermiform appendix being unperforated, a search elsewhere displays gas and fluid fæces issuing from the perforation. In some cases the perforation is situated on an easily recognized diverticulum, in which case the pouch is excised and its base is invaginated. More often the perforation is found in the midst of an indurated mass that cannot be differentiated from a carcinoma. Provided the condition of the patient is excellent right colectomy with restoration of the continuity of the intestine by lateral ileotransverse colostomy (*see* p. 231) or by the Maylard Sonnenberg technique (*see* p 434) can be undertaken. If the peritonitis is advanced, resection should not be attempted. *The right colon is mobilized as necessary (see p. 449), and that part of it containing the* perforation is exteriorized, a spigot being passed through the mesocolon in order to keep the bowel above skin level. When the patient is fit to withstand it, resection is carried out.

In all cases suprapubic drainage of the peritoneal cavity is essential.

Acute diverticulitis occurring in any portion of the colon other than the pelvic colon is comparatively favourable as regards mobilization. For instance in a case of perforation of the transverse colon associated with an abscess of the abdominal wall in the region of the umbilicus, I excised the walls of the abscess cavity without opening it, and delivered the attached transverse colon. The Paul Mikulicz procedure was accomplished without difficulty and the result was pleasing

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Fig 331 —In cases of ureteritis secondary to appendicitis the appendix is nearly always retrocecal. In this case the inflamed terminal portion of the appendix is adherent to the ureter

infrequently the consultant aids and abets him in treating the patient for "pyelitis" In no less than 80 per cent of cases falling into this group, the inflamed appendix occupies a retrocecal position.

Directly connected with this outstanding example of misleading symptomatology is the anatomical variation where an inflamed appendix is resting upon, or becomes attached to, the urinary bladder (*Fig* 332). It will be readily appreciated that in such circumstances the symptoms produced are wont to be predominantly urinary although in this instance hematuria is usually late and rare So it comes about that numbers of unfortunate individuals suffering from acute appendicitis presenting symptoms which direct attention to the urinary organs are denied the benefits of early appendicectomy

Paradoxically because a stone in the ureter often fails to produce either hematuria or increased frequency but only colic, numbers of patients harbouring a stone in the right ureter bear the scar of a recent appendicectomy a branding that affords urologists an opportunity to point a finger of scorn at the general surgeon. Be that as it may there is no gainsaying that it is better for nine appendices to be removed for stones in the ureter than for one patient with early gangrenous appendicitis to be treated as for renal colic On the other hand, if radiological facilities are available it is not difficult to avoid most of these unnecessary appendicectomies.

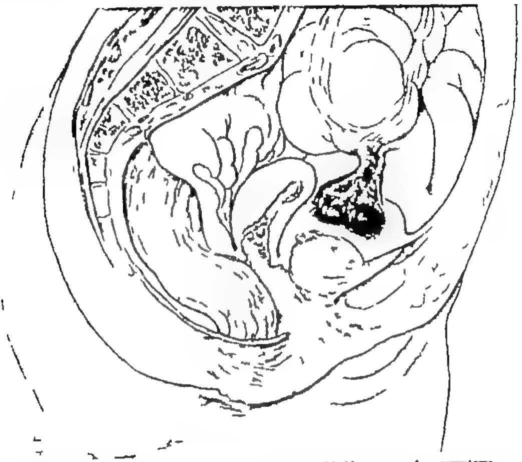

Fig 332.—An inflamed appendix in contact with the bladder may produce symptoms predominantly urinary

Urgent Excretory Pyelography —Helge Wulff collected from the records of the surgical division of the University of Lund, Sweden, nearly 500 examples of acute right-sided abdominal pain where the symptoms were mainly urinary Every patient in the series was subjected to urgent excretory pyelography Those whose right kidney and ureter could be visualized normally were hurried to the operating theatre No less than 30 of these patients were found at operation to have a gangrenous appendix lying near the right ureter As a result of this study Wulff comes to the following most important practical conclusion —*If the differentiation between early acute appendicitis and renal colic is at stake urgent excretory pyelography should be undertaken When the pyelogram shows a normal outline appendicectomy should be performed forthwith* To emphasize the value of this dictum, he quotes the following instructive case —

A man, aged 60 seven years previously had had an attack of right-sided abdominal pain, which proved to be due to a ureteric calculus. A calculus the size of a hemp seed was passed. The present attack commenced at 10 p.m., and one hour later he was found to be rigid and tender on the right side of the abdomen. The pulse and temperature were normal. The urine was tinged red, and microscopical examination showed many red corpuscles. Excretory pyelography revealed that both kidneys and ureters were functioning normally Urgent appendicectomy was undertaken. The appendix was completely gangrenous and unperforated.

In a number of instances where I could not make up my mind as to whether a patient was suffering from renal colic or early acute appendicitis, I have performed urgent cystoscopy and when facilities existed, have invoked the aid of radiology as well. With a catheterizing cystoscope alone one can often prove that the patient is suffering from a lesion of the right ureter. On several occasions after a ureteric catheter has been passed up the right ureter a brisk dripping of limpid urine through the lumen of the catheter has resulted *in immediate amelioration of symptoms.*

Management and Treatment of Renal Colic.—*See* Chapter LI

TORSION OF AN APPENDIX EPIPLOICA

There are about 100 appendices epiploicæ in the average adult and they are most conspicuous on the transverse and sigmoid segments of the colon. It is more than probable that some of those cases where the abdomen is opened and one is astounded to

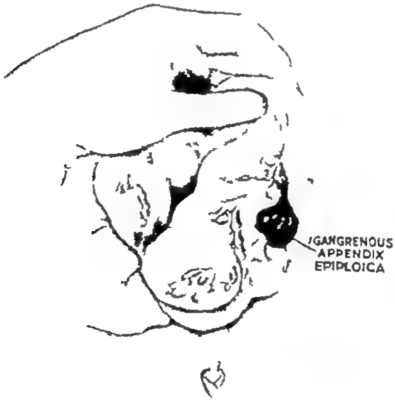

Fig. 233.—Torsion of an appendix epiploica.

find no obvious lesion to account for the symptoms, are examples of torsion of an appendix epiploica (*Fig.* 233). If it were possible to scrutinize the whole of the large intestine the lesion would be revealed *more often.*

Clinical Features. The condition can occur at any age, the maximum incidence being in the third and fourth decades. Without exception, an acute attack commences suddenly with severe, sometimes colicky pain. Although the pain is often experienced in the umbilical region, it varies with the site of the affected appendix epiploica (*Fig.* 234). Nausea and *vomiting are unusual.* Most cases are referred to the surgeon comparatively late, the average duration of the symptoms being 3.3 days (Murdie). Leucocytosis was present in 23 out of 32 cases where this investigation was *carried out.*

Treatment.—The twisted base is transfixed and ligated and the appendix epiploica snipped off with scissors. Care should be taken to apply the ligature a little way from the colon, as a diverticulum is sometimes present in relation to the base of an appendix epiploica. After excision of the diverticulum the base should be invaginated by a purse-string suture.

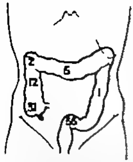

Fig 334.—Sites of a twisted appendix epiploica from 108 cases collected from the literature (*After W Murdie*)

Reflecting on this condition, it is certain that Nature would in all probability deal effectively with all cases. The gangrenous appendage (the gangrene is abacterial or virtually so) would drop off and form a small loose body in the peritoneal cavity. The insuperable difficulty is that we can never hope to diagnose this condition, even tentatively; we can only bear it in mind.

TORSION OF THE GREATER OMENTUM

In 80 per cent of cases the condition is mistaken for appendicitis with unusual symptoms; in women the alternative diagnosis is usually a twisted ovarian cyst. That the torsion usually presents in the right iliac fossa is explained by the fact that the right side of the greater omentum is larger and more mobile. The twisted omentum, depleted of its blood supply, may become gangrenous (*Fig* 335) and give rise to peritonitis.

F. W., aged 28, gave a history of five days' general abdominal pain. Twenty-four hours before admission he gave up work and went to bed. He had not vomited, and there was no history of a previous attack. The pulse and temperature were normal. On examination, he pointed to the right iliac fossa as the site of the most acute pain. There was considerable general abdominal tenderness, but no rigidity. An ill-defined lump could be palpated in the right iliac fossa. A diagnosis of unperforated appendicitis was made.

Under the anæsthetic the lump could be clearly demonstrated, and was movable. It was thought that it was probably an acute appendix wrapped in omentum. The abdomen was opened by a rectus-splitting incision and a small quantity of blood-stained fluid escaped. The lump was found to be a piece of greater omentum about the size of a tangerine orange, the neck of which was pedunculated and obviously twisted. On being excised the mass was found to be quite gangrenous. No other abnormality was found. The appendix was removed, and appeared quite normal. Recovery ensued.


Fig 335.—Torsion of the great omentum. (*W Etherington-Wilson, British Journal of Surgery.*)

An important point to be remembered is that torsion of the greater omentum is one of the causes of blood-stained fluid in the peritoneal cavity. Untwisting may be attempted, but it is usually impossible. In any case the base of the twisted mass should be ligated securely and the mass excised.

PRIMARY IDIOPATHIC SEGMENTAL INFARCTION OF THE GREATER OMENTUM

The colour changes, viz. an intense red in early cases and blue-black in cases of some standing, are the same as those of torsion of the greater omentum, but there is no twisting to account for it. It should be noted, however, that infarction occurs in an area of the greater omentum where torsion is unlikely. The area affected is more or less wedge-shaped at the free edge of the greater omentum. As in torsion of the greater omentum there is often blood-stained fluid in the peritoneal cavity. The affected area should be excised. Seeing that practically all cases of both torsion as well as infarction of the

greater omentum are diagnosed as acute appendicitis, when the appendix is found to be blameless and there is blood-stained fluid in the peritoneal cavity. In the absence of an obvious lesion the greater omentum should always be scrutinized.

ACUTE NON-SPECIFIC MESENTERIC LYMPHADENITIS

There is a distinctly higher incidence of acute mesenteric adenitis during the months in which infections of the upper respiratory tract are prevalent.

The patient is most often a male between the ages of 3 and 10 years, but the condition sometimes occurs in adolescents and adults. The attacks are usually recurrent. There are spasms of severe general abdominal colic with intervals of complete freedom—complete freedom from pain never occurs in appendicular colic. This should lead one

Fig. 330.—Acute non-specific mesenteric lymphadenitis. (*After A. P. Bell.*)

to suspect the condition. Nausea and sometimes vomiting accompanies the attack. The temperature is raised, and there is a leucocytosis of 12,000 cu. mm. or more on the first day of the attack, but this falls on the second day. The initial reading is higher and falls more rapidly than in acute appendicitis. The point of maximum tenderness is higher and more medial than is usual in acute appendicitis. The most valuable differentiating sign is shifting tenderness. After lying the patient on the left side for a few minutes, the site of maximum tenderness referred to changes to the level of the umbilicus or to the left of that point. Sometimes the condition is mildly epidemic and is preceded by upper respiratory infection.

Many times I have removed the appendix to discover it was doubtfully diseased or healthy, and the mesenteric lymph nodes were enlarged (*Fig. 330*). On a few occasions I have suspected non-specific mesenteric lymphadenitis, and have displayed an acutely inflamed appendix. The diagnosis of acute mesenteric lymphadenitis may be made before operation, but it is dangerous to be so sure of the diagnosis as to withhold operation (Postlethwait and Campbell).

Summarizing.—Unless early acute appendicitis can be ruled out definitely, it is far better to operate.

See also SUPPURATING MESENTERIC LYMPHADENITIS (p. 206)

ACUTE PHLEGMONOUS CÆCITIS AND COLITIS

Acute phlegmonous inflammation, well recognized in the case of the stomach (see p. 302), can also attack the duodenum, the small intestine, and the large intestine. When the large intestine is the seat of this rare condition it is the cæcum, or the ascending colon, that is usually affected. A normal appendix is found in all cases, except when the appendix *has become inflamed by contiguity*.

Acute phlegmonous cæcitis (or colitis) can be circumscribed (*Fig.* 337) or diffuse. The lesion commences as a cellulitis of the submucosa.

Diagnosis.—Most cases of acute phlegmonous cæcitis have been diagnosed as either acute appendicitis or as an appendix abscess. A mass appears in the right iliac fossa *early, even during the first 48 hours.*

Fig. 337.—Acute circumscribed phlegmonous cæcitis (*R. E. B. Tagart*). (*By kind permission of the British Journal of Surgery.*)

Treatment.—If circumscribed phlegmonous cæcitis or colitis without gangrene or perforation is found at laparotomy, removal of the lesion is unjustifiable. After suturing a free omental graft over the area of inflammation, closure of the abdomen with corrugated rubber drainage, followed by antibiotic therapy, is the correct treatment. In cases where perforation appears imminent, local excision, preferably by diathermy, and closure of the defect in layers, ileocolostomy or exteriorization of the affected portion can be undertaken as circumstances dictate. It goes without saying that full antibiotic therapy must be instituted.

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CHAPTER XXII

EMERGENCIES CONNECTED WITH MECKEL'S AND OTHER DIVERTICULA OF THE SMALL INTESTINE

As is well known Meckel's diverticulum is present in 2 per cent of the human race. It is situated upon the antimesenteric border of the small intestine 2 ft. (60 cm.) from the ileocæcal valve and is usually 2 in. (5 cm.) long. What is not so well known is that the diverticulum, unlike acquired diverticula of the colon, is composed of the same three layers that make up the ileum, but in 20 per cent of cases the innermost layer contains heterotopic epithelium. This takes the form of gastric, duodenal, jejunal, or colonic epithelium or pancreatic tissue. The most common variety of heterotopic tissue is gastric mucosa, and it occurs in 16·6 per cent of all cases; the presence of aberrant gastric glands capable of pouring forth acid and pepsin under the same hormonic control as the stomach is responsible for peptic ulceration in or adjacent to the diverticulum. When present heterotopic tissue usually lines the greater part of the diverticulum, often involving the neck of the pouch and not infrequently extending into the nearby ileum, also. Peptic ulcers that give rise to hæmorrhage (and also those that perforate) are situated most frequently in the neck of the diverticulum (*Fig.* 338).

Fig. 338.—The location of the lesion in 45 cases of peptic ulceration occurring in Meckel's diverticula. (*After D. H. Cobb.*)

Statistics indicate that males possessing a Meckel's diverticulum outnumber females in the ratio of 3 : 1. Infrequently Meckel's diverticulum possesses a mesodiverticulum. In nearly 90 per cent of cases the diverticulum arises on the antimesenteric border; in the remainder it is situated near the mesenteric border. Exceptionally the diverticulum is intramesenteric and requires transillumination to reveal it.

When a silent Meckel's diverticulum is encountered in the course of an abdominal operation, provided the diverticulum can be excised without appreciable additional risk this should be done. The wisdom of this advice has been confirmed by the frequency and severity of the complications that are liable to ensue in connexion with this anomalous structure.

The diverticulum may remain symptomless throughout life and is found at necropsy. In a case of Meckel's diverticulum giving rise to symptoms, failure to visualize a diverticulum by radiography after a barium meal is of no significance because so often the entrance of the diverticulum is blocked by œdema.

MECKEL'S DIVERTICULUM CAUSING URGENT SYMPTOMS

In an analysis of 1605 cases of Meckel's diverticulum collected from the literature Moses found the acute disorders connected with the diverticulum were as follows:—

Intestinal hæmorrhage	490 (30·9 per cent)
Intestinal obstruction	383 (23·8 per cent)
Diverticulitis	163 (10·8 per cent)

The complications of Meckel's diverticulum in childhood have been stressed by many writers. While such studies are valuable, the importance of these complications in adults has been overshadowed by these communications. In a series of 16 cases occurring at the Central Middlesex Hospital two-thirds occurred in patients between the ages of 21 and 61. Large series of cases show that while symptoms may become manifest at any age they do so more frequently during the first, second, and third decades.

Serious Hæmorrhage per rectum from a Meckel's diverticulum (due to peptic ulceration) occurs most frequently between the ages of 10 and 15 years, but it is not uncommon in adults. Observing that the characteristic blood passed per rectum is dark red in colour

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—intermediate between the tarry stool of melæna from a bleeding duodenal ulcer and the bright red hæmorrhage from a lesion of the colon—provided the patient is a child or a youth it is not difficult to strongly suspect a Meckel's diverticulum as the site of the hæmorrhage. In infants, the hæmorrhage is first likely to be attributed to an intussusception, but the absence of a lump in the abdomen and the fact that there is no mucus admixed with the blood should direct the clinician's thoughts to a Meckel's diverticulum. In adults it is much more difficult to even suspect Meckel's diverticulum as the source of the hæmorrhage. A feature of value in differential diagnosis is that if vomiting occurs, which is not unusual, the vomit contains no blood.

Hæmorrhage, penetration, or perforation of a peptic ulcer connected with a Meckel's diverticulum may be, or more usually is not, preceded by pain. When pain does occur it is commonly periumbilical colic and is due to distension of the diverticulum and juxta ileum by *fluid blood or clots*. *Sometimes bleeding precedes perforation.*

When operative treatment is required for uncontrollable melæna, and at laparotomy there is no visible or palpable lesion in the stomach or the duodenum, before proceeding further it is an excellent practice to examine the last 2 ft. of the ileum for a Meckel's diverticulum. When a Meckel's diverticulum is the source of the bleeding, *the terminal ileum and the large intestine can be seen filled with blood, whereas in the rest of the small* intestine blood is absent.

Diverticulitis with or without Perforation.—Meckel's diverticulum is liable to become inflamed (*Fig.* 339), when it gives rise to symptoms and many of the signs similar to those of appendicitis. It is impossible to distinguish between these two conditions, except in the rare event of the patient having undergone appendicectomy previously. Even so probably a diagnosis of perforated duodenal ulcer will be made. When perforation of a Meckel's diverticulum (*Fig.* 340) occurs, diffuse peritonitis follows quickly, and is more lethal than that occurring with perforated appendicitis, owing to the fact that the diverticulum is placed more centrally and there are fewer anatomical barriers to the rapid extravasation of liquid fæces. An important precipitating factor in the development of acute inflammation is the accumulation in the pouch of coarse intestinal residue, or lodgement of a foreign body. *In several* cases of peritonitis (usually diffuse) the diverticulum has been found perforated by a fishbone. In Lindquist's case the perforation was due to a sharp piece of wood.

Fig. 339.—Acute Meckel's diverticulitis.

Fig. 340.—Excised Meckel's diverticulum showing a perforation. (*J. T. Chesterman, British Journal of Surgery.*)

Meckel's Diverticulum as a Cause of Intestinal Obstruction.—*See* p. 429

MECKELIAN DIVERTICULECTOMY

A Meckel's diverticulum should not be amputated and its base invaginated in the same way as an appendix, because often this is a cause of considerable narrowing of the intestine. For routine excision the following technique is satisfactory. In the unusual event of a mesodiverticulum being present this is divided between hæmostats near its mesenteric attachment, and ligated. Two Kocher's clamps are placed obliquely across the base of the diverticulum as shown in *Fig.* 341, and the diverticulum is excised by cutting between the clamps (*Fig.* 342), preferably with a diathermy needle. For closure it is sufficient to employ a single row of closely placed mattress sutures of thread[1] (*Fig.* 343). The obliquity of the line of suture (*Fig.* 344) prevents narrowing of the intestine. It is a wise precaution to cover the area with a free omental graft, more especially to minimize subsequent adhesions.

[1] Ferments from islets of ectopic pancreatic tissue have been known to digest catgut sutures.

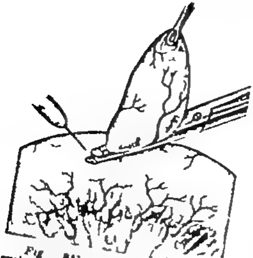

Fig 841 —The diverticulum is excised, preferably with a diathermy needle as shown. Note the obliquity of the clamps in relation to the long axis of the intestine

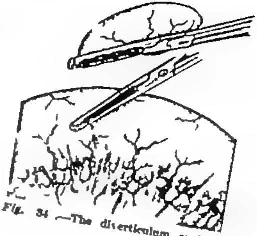

Fig. 34 —The diverticulum excised.

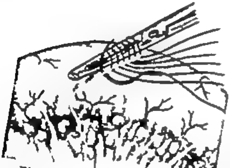

Fig. 848.—Mattress sutures are inserted over the clamp. This method constitutes aseptic resection.

Fig. 844—Oblique resection, and suture in this manner does not narrow the lumen of the intestine

Fig 315.—Wedge resection of a Meckel's diverticulum.

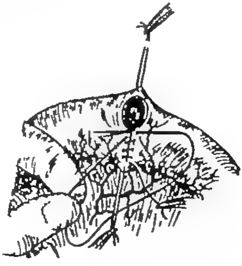

Fig. 316.—Repair of same

A diverticulum with an indurated or perforated base more than probably contains œdematous gastric or pancreatic epithelium, and diverticulectomy by the method described becomes inapplicable. In such cases a wedge resection with appropriate repair as shown in *Figs.* 345 346, usually suits the case.

When the amount of induration around the base is considerable, and particularly when it extends into the neighbouring ileum, it is advisable to resect a short segment of the ileum containing the diverticulum, and to restore the continuity of the bowel by end to-end anastomosis, or by the method of Poth (*see* p 406).

OTHER DIVERTICULA OF THE SMALL INTESTINE

Diverticula of other parts of the small intestine, especially of the upper jejunum can also give rise to severe hæmatemesis and melæna, and on occasions one of these diverticula

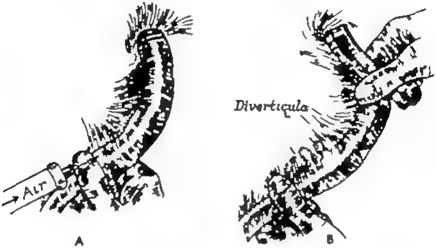

Fig 347 —A, Air is injected i to the jejunum by a syringe and needle B With the jejunum occluded by compression distal to the diverticula, stripping is conducted as shown in order to distend the diverticula with air (*After C W Mayo et al*)

Fig 348.—Hæmorrhage from jejunal diverticula resected specimen. (*I M Orr and J N W Russell.*)

perforates. A bleeding jejunal diverticulum is sometimes situated on the mesenteric border of the intestine, and is difficult to find, even after radiological confirmation of its presence In order to demonstrate such diverticula at operation, C. W Mayo advises

inflation of the jejunum with air by means of an aspirating syringe (*Fig.* 347 A) and by milking the air into various parts of the jejunum diverticula, if present, are displayed by becoming ballooned (*Fig.* 347 B). Resection of that segment bearing the diverticulum (*Fig.* 348) is the only satisfactory method of treating a bleeding jejunal diverticulum.

A *perforated* jejunal diverticulum is nearly always situated on the antimesenteric border of the intestine. The best treatment is excision of the diverticulum.

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CHAPTER XXVII

PERFORATED GASTRIC AND DUODENAL ULCER

Perforation of a gastric or duodenal ulcer is one of the most serious and most overwhelming catastrophes that can befall a human being.—LORD MOYNIHAN.

First-aid Treatment.—To administer morphine to a patient with undiagnosed abdominal pain before sending him to hospital is a pernicious practice still too much in evidence.

If a perforated peptic ulcer is even suspected, why not pass a gastric aspiration tube and empty the stomach forthwith? Keep the tube in place and, particularly if the patient has a long ambulance journey before him, have the stomach emptied at intervals. As the majority of peptic perforations are on the right of the middle line the patient should be encouraged to lie on his *left side*: this will minimize the escape of fluid into the peritoneal cavity. Common sense dictates that these easily applied measures must minimize leakage and thereby delay and localize peritonitis. *Gastric aspiration for the prevention of unbridled outpouring from a gastric or duodenal perforation* should become a first-aid ingrained principle in the management of these cases by the whole profession.

The Inestimable Value of Early Diagnosis.—There is no intra-abdominal catastrophe where a successful outcome is more dependent upon early diagnosis and prompt transportation (*Fig.* 349). Especially in the great urban districts, the improvement during the past twenty years in both these desiderata has been noteworthy, but there is still room for general improvement in earlier diagnosis, particularly among female patients and elderly men (the catastrophe is very rare in elderly women). Because of the comparative rarity of perforated peptic ulcer in women, general practitioners are liable to attribute the symptoms and signs to other conditions, notably gall-stone colic, and having arrived at the latter diagnosis, to administer morphine.

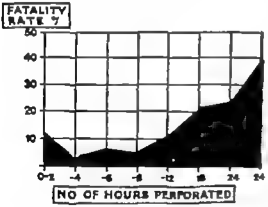

Fig. 349.—Deaths by delay in operation. (*After R. L. Jamieson.*)

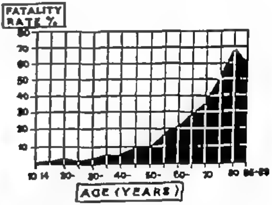

Fig. 350.—Fatality rate for perforated peptic ulcer (1944–53). (*After R. A. Jamieson.*)

Age and Sex.—In assessing methods of treating perforated peptic ulcers and also the published mortality figures relating thereto, it is important to take into consideration the type of individual who is stricken with this catastrophe. The sex and average age of the victim vary enormously not only from decade to decade but geographically. Prior to about 1912 the majority of patients were women: reports that as many as 70 per cent of the patients were females were not uncommon in individual series. By 1920 it was rare for more than 2 per cent of any series of cases to be females. The great preponderance of males remains a notable feature of perforated peptic ulcer, but this preponderance is less than it was a decade ago. During 1924–43 the ratio was 19 males to 1 female; during 1944–53 the ratio was reduced to 12 males to 1 female (Jamieson). The practical outcome of this assessment should be that a sharper look-out be kept for cases of a peptic perforation in females.

The country and even the district, in which the surgeon practises makes a difference as to the type of individual he will be called upon to treat, and also the number of hours which will have elapsed before the patient reaches the hospital. Regarding the former factor the observations made in 1938 by A. M. Graves are pertinent. He wrote: "The perforated peptic ulcer patient in Germany differs from the one often pictured by American authors. He is usually a strong well nourished individual who eats an excessive amount of coarse foods, drinks a considerable volume of fluids, and works hard. Sixty per cent of perforations occur in labourers."

While it is obvious that with advancing years the recovery rate from any major disaster will be correspondingly lower (*Fig* 330), it is not appreciated sufficiently that perforated peptic ulcer is a condition that can and does, occur in sexagenarians septuagenarians, and octogenarians. Elderly male patients, like women in the prime of life with peptic perforations are too often sent to hospital late—and for the same reason.

As is emphasized in several chapters of this work, one should never "throw in the sponge" on account of old age. Perforated peptic ulcer is no exception to this aphorism. Successful closure of a perforated peptic ulcer has been performed in patients aged 82 (Sandell) and 81 (Norris) My oldest patients with this condition who survived were 79 and 76 respectively while Tanner has had five recoveries between the ages of 77 and 79 Coming to the other extremity of life, perforated peptic ulcer occurs occasionally in children, and even in the newborn.

Peritoneal Cultures following Perforation.—A higher incidence of positive cultures is obtained by collecting some of the peritoneal fluid for implantation in the culture medium than when a swab dipped in the exudate is submitted For the first 10 hours cultures are often sterile because of the bacteriostatic effect of hydrochloric acid from the stomach the peritonitis at this time, although often intense, is a chemical peritonitis. After 12 hours inhibition due to the acid is no longer present, and staphylococci, streptococci, and colon bacilli are then often encountered, the first two being found most frequently

Fig 331 —Crescentic gas-shadow beneath the right cupola of the diaphragm. Perforated duodenal ulcer seven hours duration. (*The London Hospital Radiological Department.*)

Radiography—A plain radiograph that reveals a crescentic translucent area beneath the right cupola of the diaphragm (*Fig* 331) confirms the diagnosis of perforated peptic ulcer and is extremely valuable in atypical cases. Radiographs should be taken as early as possible after the perforation, because *small* amounts of air are absorbed rapidly The left lateral decubitus gives the highest percentage of positive results, but films in the erect position should be taken also. *However* the time expended and the manipulations involved are unwarranted except when the diagnosis is in doubt (coronary thrombosis, pneumonia and acute pancreatitis can all, on occasions, simulate a perforated peptic ulcer) or in the event of non-operative treatment being advised. In about 70 per cent of cases of perforated peptic ulcer air can be demonstrated beneath the diaphragm, whereas negative findings accrue in at least 20 per cent the remainder are indefinite In cases of real

clinical doubt, for instance when the patient has been given morphine, after the gastric contents have been aspirated 20–30 ml. of air can be injected into the stomach. The patient lies on his left side for a few minutes, and then a radiograph is taken in the sitting posture. In these circumstances if a perforation is present the crescentic translucent area referred to will be seen in a very high percentage of cases.

Operation has been decided upon.—Once the diagnosis has been settled by the surgeon who is about to operate, morphine can be administered, but written permission for operation should be obtained before this drug is given. The relief morphine affords may be followed by refusal or delay of *the patient to submit to treatment. Morphine helps in several ways.* It saves the patient at least twenty minutes agony It allows the abdomen to be shaved and prepared before the anaesthetic above all, it means less anaesthetic and more relaxation, important factors when dealing with muscular men.

LOCAL INFILTRATION OF PROCAINE SOLUTION COMBINED WITH INTRAVENOUS THIOPENTONE

For suture of a perforated peptic ulcer this form of combined anaesthesia is unexcelled, and is followed by a very low incidence of pulmonary complications. It is of cardinal importance to avoid an inhalation anaesthetic in unselected examples of this catastrophe.

Although the procedure is absolutely simple, and, if carried out in the manner about to be detailed, it is safe experience shows that there are a surprising number of possible errors and misunderstandings, many of which may spell disaster Among these mistakes are injecting the thiopentone solution into the rubber tubing near the interceptor as opposed to near the vein injecting the thiopentone, and then turning on the saline (which was dripping slowly) to a faster rate all eyes focused on the operation or the patient's face the receptacle containing the saline solution has been allowed to run dry preparing two 1 G doses of thiopentone (larger ampoules) instead of two ½-G doses.

Technique.—

In the Ward.—The stomach is emptied with a gastric aspiration tube, which is left in place The patient is given a suitable dose of morphine and his eyes are blindfolded securely He is transported to the operating theatre.

In the Operating Theatre.—Intravenous fluid therapy (usually dextrose-saline) is commenced, continued throughout the operation and as long afterwards as is deemed necessary

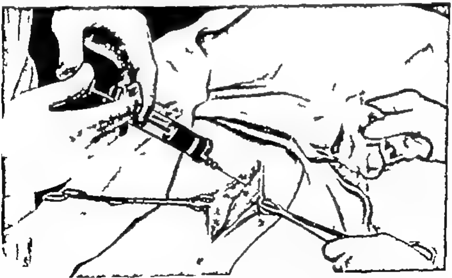

Fig. 332.—Infiltrating the muscle with procaine solution.

Haste is unnecessary Once the fluid is dripping into the circulation, unless he is moribund the patient's general condition commences to improve rather than to deteriorate If necessary he can receive a pint of plasma before the introduction of the intravenous dextrose-saline solution Indeed until the patient has an adequate blood-pressure (at least *a systolic pressure of 110 mm. Hg)* the operation should not be commenced. The abdomen

can be shaved and prepared more conveniently than if he were in bed. The theatre staff preparing for the operation should be instructed to carry out their duties quietly and told that as there is no undue haste, there is no excuse for clattering instruments.

Preparing the thiopentone solution The anæsthetist takes two ½-G ampoules of thiopentone and two corresponding ampoules of sterile water Providing himself with two 10-ml. syringes, he proceeds to fill each, and thus has two 10-ml. doses of a [illegible] per cent solution of thiopentone in readiness.

Having made the necessary preparation and having ascertained that the patient's condition is satisfactory and that the gastric aspiration commenced in the ward is proceeding smoothly what may be termed the operation proper can be commenced.

Infiltration of the abdominal wall The skin from the umbilicus to the xiphisternum is infiltrated with 1 per cent procaine. A midline incision is made in the skin. There is usually little or no bleeding The skin edges are grasped in Lane's forceps. After a little undermining of the skin edges on either side each rectus sheath is infiltrated with local anæsthetic thoroughly (*Fig* 332).

Introducing thiopentone into the circulation (*Fig* 333) The saline solution must be running at a rate of at least 50 drops a minute. The anæsthetist sterilizes the rubber tubing near the cannula and injects ½ G of thiopentone into the lumen of the rubber tube in exactly the same way as it would be injected directly into a vein i.e., very slowly 0·1 G at a time While the thiopentone is being injected a nurse sits on the anæsthetist's seat at the head of the table, encourages the patient tells him to count loudly and has her hands in readiness to hold the jaw forward should this become necessary When the injection has been completed the anæsthetist returns to the patient's head. Unconsciousness is sometimes delayed a little longer than in the case of a direct injection into the vein. Usually the respirations become somewhat shallow and the patient tends to become cyanosed. In all cases the lower jaw must be held forward, and in many instances oxygen should be administered.

We will assume that the patient has fallen asleep that he is somewhat cyanosed, and that the anæsthetist is attending to him.

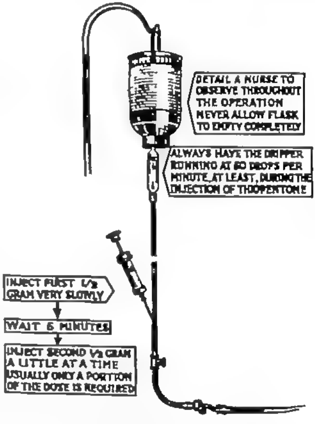

Fig. 333.—Symposium of essential details for supplementing local infiltration with intravenous anæsthesia.

Opening the peritoneum While the above has been proceeding the surgeon has clipped towels to the wound edges, has completed the middle line incision, and has opened the peritoneum. Again it is emphasized that there is absolutely no hurry Time can be well spent sucking fluid from the peritoneal cavity If all is well with the patient, the operation proceeds, and after a lapse of five minutes, a portion of the second ½ G of thiopentone is injected according to the needs of the case Usually after a lapse of five minutes, the abdominal wall is well relaxed[1] and the patient's colour is a satisfactory pink. All that is necessary is to give just sufficient thiopentone in 0·1 G doses to keep him asleep the local anæsthetic [illegible] in full operation as far as the abdominal wall is concerned.

To illustrate what can be accomplished with this form of combined anæsthesia, I sutured successfully a perforated gastric ulcer in a patient at 2 a.m. in a small nursing home

[1] The administration of relaxants is not discussed, for it belongs to the province of anæsthesiology

during an air raid. *As, owing to the circumstances, no medical assistance could be obtained,* a nurse injected the thiopentone under my instructions.

Plasma as the Vehicle.—In exceptional circumstances it may be advisable to carry out the operative procedure while the patient is having the plasma infusion. Under such circumstances it is necessary to speed up the flow of plasma while the thiopentone is being injected into the tubing. Consequently it is advisable to fix a Higginson's syringe on to the inlet glass tube of the bottle of plasma or better to employ a Martin's pump (*see* p. 50). In this way plasma can be substituted for dextrose-saline solution and the rate of flow of plasma is so speeded up as to render it comparable to that of an electrolyte solution. Only in these *circumstances can thiopentone be injected safely.*

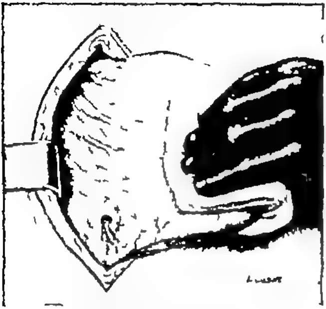

Fig. 334.—Method of holding the stomach when searching for and closing a perforated peptic ulcer

Displaying the Perforation.—When the peritoneum is opened, the operator *should listen intently*: otherwise a muffled pop of escaping gas may pass unnoticed: this phenomenon is present in under 10 per cent of cases.

Unless the perforation is a small one, fluid gushes forth with each expiration. When enough fluid has been mopped up (or sucked out) to enable its anterior surface to be seen clearly the stomach near the greater curvature is grasped in the right hand with a moist abdominal pack (*Fig.* 334). The left hand contains another pack, and by wiping the stomach and duodenum the perforation is sought. Obviously it is best to commence looking for the perforation where fluid is welling up most plentifully. In this connexion a pitfall must be known. When the perforation has occurred into the lesser sac (i.e., the ulcer is on the *posterior surface of the stomach) the fluid pours out* of the foramen of Winslow: this makes one think that it is the anterior surface of the duodenum which has perforated. *In eight cases out of ten the perforation is located easily.*

Perforations high on the lesser curvature are certainly difficult of access, but if the midline incision recommended in this work has been employed, by *extending the incision right up to the xiphisternum* the perforation can usually be displayed adequately.

Methylene Blue for Quick Localization of the Perforation.—When the perforation is not found easily, if the anæsthetist injects 50–60 ml. of a 1 per cent solution of methylene blue down the gastric aspiration tube, the site of the perforation becomes readily apparent (*Fig.* 335). One per cent of methylene blue in normal saline which has been autoclaved should be kept in suitable quantities for this purpose in the operating theatre. The ready-for-use capsules of indigo-carmine used in chromocystoscopy also serve for this purpose.

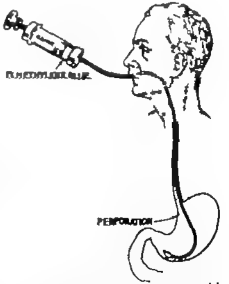

Fig. 335.—Methylene blue to aid quick localization of an elusive perforated peptic ulcer. (*After Jaffe.*)

The hole having been found, retraction of the abdominal wall and traction upon the stomach are so arranged as to bring the perforation into the best possible view. This position is maintained by the assistant. Further to aid exposure it is often advisable to insert an abdominal pack, in order to tuck away the transverse colon.

Closing the Perforation.—The best method of closing the perforation is to employ interrupted catgut sutures on a medium-sized curved, round-bodied needle. The first stitch is placed a little distance from the perforation. A considerable bite of the stomach wall (*Fig* 336) is taken with the stitch in order to prevent cutting out, which is prone to occur especially in oedematous tissues. This stitch is the key to the situation, and as soon as it has been tied and it has been ascertained that it will hold, the stitch can be employed as an efficient retractor The next interrupted stitch is inserted in the same way and tied and so on until the perforation has been closed. When the surgeon considers that sufficient stitches have been inserted, their long ends are cut short, except the first and the last. These are retained in order that the suture line may be examined if it passes inspection and the condition of the patient is satisfactory the suture line should be reinforced (*see below*).

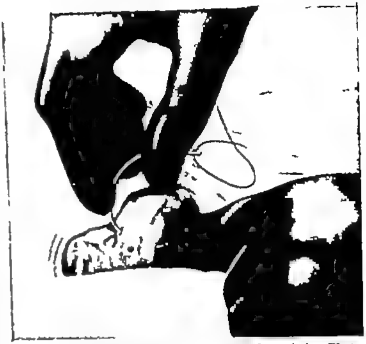

Fig. 336.—Closing the perforation, the first stitch Photograph of an actual case. The perforation is situated in the first part of the duodenum.

When, on inspecting the suture line, doubt is felt regarding its integrity probe the suspicious area (*Fig* 337) with a view to finding a crevice an extra stitch may be deemed advisable.

Fig. 337.—A large perforated gastric ulcer has been sutured, and a Watson Cheyne dissector is being used to ascertain if the suture line is secure.

Reinforcing the Suture Line.—

1 *The gastro-hepatic omental flap* When the perforation is situated near the upper border of the anterior surface of the first part of the duodenum (a very common situation) it is remarkable how often a suitable little flap of lesser omentum having an attachment to the upper border of the juxtapyloric portion of the duodenum is present. Seize the free border of this flap delicately but firmly in a hæmostat and draw it over the suture line. So frequently can it be made to cover the area of the perforation without tension that one is inclined to conjecture that Nature has provided material for patching a perforation just where it is required most often. When the flap cannot be drawn over the area without tension, a snip with scissors here and there in an avascular area near the base of the flap will frequently render it more mobile.

Having prepared the flap as required, and having spread it over the sutured perforation using, if necessary another hæmostat (*Fig* 358), the flap is stitched down with interrupted unabsorbable sutures so as to form a patch in the true meaning of the term (*Fig* 358, inset).

during an air raid. As, owing to the circumstances, no medical assistance could be obtained, a nurse injected the thiopentone under my instructions.

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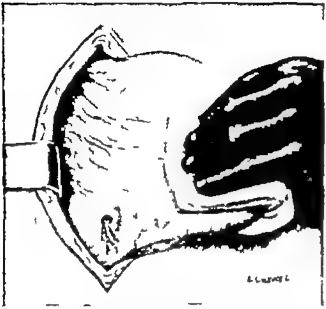

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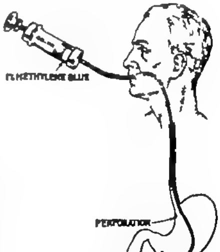

Fig. 355.—Methylene blue to aid quick localization of an elusive perforated peptic ulcer. (*After J. Fle.*)

The hole having been found, retraction of the abdominal wall and traction upon the stomach are so arranged as to bring the perforation into the best possible view. This position is maintained by the assistant. Further to aid exposure it is often advisable to insert an abdominal pack, in order to tuck away the transverse colon.

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Fig 356.—Closing the perforation; the first stitch. Photograph of an actual case. The perforation is situated in the first part of the duodenum.

When, on inspecting the suture line, doubt is felt regarding its integrity probe the suspicious area (*Fig* 337) with a view to finding a crevice an extra stitch may be deemed advisable.

Fig 357.—A large perforated gastric ulcer has been sutured, and a Watson Cheyne dissector is being used to ascertain if the suture line is secure.

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Having prepared the flap as required, and having spread it over the sutured perforation using, if necessary another hæmostat (*Fig* 358), the flap is stitched down with interrupted unabsorbable sutures so as to form a patch in the true meaning of the term (*Fig* 358 inset).

during an air raid. As, owing to the circumstances, no medical assistance could be obtained, a nurse injected the thiopentone under my instructions.

Plasma as the Vehicle.—In exceptional circumstances it may be advisable to carry out the operative procedure while the patient is having the plasma infusion. Under such circumstances it is necessary to speed up the flow of plasma while the thiopentone is being injected into the tubing. Consequently it is advisable to fix a Higginson's syringe on to the inlet glass tube of the bottle of plasma or better to employ a Martin's pump (see p. 50). In this way plasma can be substituted for dextrose-saline solution and the rate of flow of plasma is so speeded up as to render it comparable to that of an electrolyte solution. Only in these circumstances can thiopentone be injected safely.

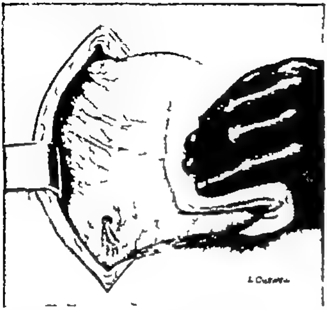

Fig. 354.—Method of holding the stomach when searching for and closing a perforated peptic ulcer.

Displaying the Perforation.—When the peritoneum is opened, the operator should listen intently; otherwise a muffled pop of escaping gas may pass unnoticed: this phenomenon is present in under 10 per cent of cases.

Unless the perforation is a small one, fluid gushes forth with each expiration. When enough fluid has been mopped up (or sucked out) to enable its anterior surface to be seen clearly the stomach near the greater curvature is grasped in the right hand with a moist abdominal pack (*Fig.* 354). The left hand contains another pack, and by wiping the stomach and duodenum the perforation is sought. Obviously it is best to commence looking for the perforation where fluid is welling up most plentifully. In this connexion a pitfall must be known. When the perforation has occurred into the lesser sac (i.e. the ulcer is on the posterior surface of the stomach) the fluid pours out of the foramen of Winslow; this makes one think that it is the anterior surface of the duodenum which has perforated. *In eight cases out of ten the perforation is located easily.*

Perforations high on the lesser curvature are certainly difficult of access, but if the midline incision recommended in this work has been employed, by extending the incision right up to the xiphisternum the perforation can usually be displayed adequately.

Methylene Blue for Quick Localization of the Perforation.—When the perforation is not found easily, if the anæsthetist injects 30–60 ml. of a 1 per cent solution of methylene blue down the gastric aspiration tube the site of the perforation becomes readily apparent (*Fig.* 355). *One per cent of methylene blue in normal saline which has been autoclaved should be kept in suitable quantities for this purpose in the operating theatre.* The ready-for-use capsules of indigo-carmine used in chromocystoscopy also serve for this purpose.

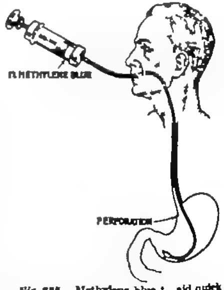

Fig. 355.—Methylene blue to aid quick localization of an elusive perforated peptic ulcer. (*After Jaffe.*)

The hole having been found, retraction of the abdominal wall and traction upon the stomach are so arranged as to bring the perforation into the best possible view. This position is maintained by the assistant. Further to aid exposure, it is often advisable to insert an abdominal pack, in order to tuck away the transverse colon.

Looking for a Second Perforation.—It is worth while making a practice of looking for a second perforation a few seconds will suffice. Several examples of simultaneous perforation of two ulcers have been reported, and I have seen at necropsy a case where one perforated ulcer had been closed satisfactorily and another perforation had been overlooked.

Removing Extravasated Fluid.—The advent of the mechanical sucker has helped in no small measure to improve the results of operations for perforated peptic ulcer for it removes the fluid without disturbance and without abrasion of the peritoneal coat of the viscera. There are still many hospitals without a mechanical sucker and suckers,

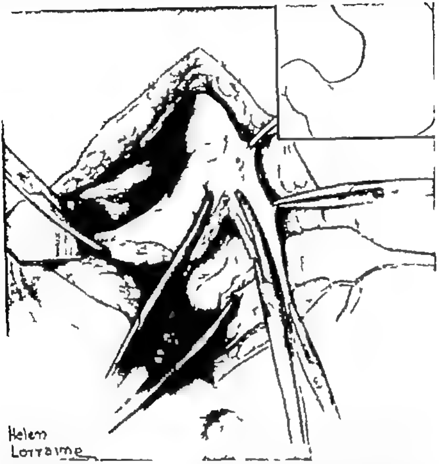

Fig 261.—Fontana method. Showing the round and falciform ligaments freed from their attachment inferiorly and laterally and ready to be utilized for patching a sutured perforated lesser curve ulcer. Inset shows the area of the stomach where Fontana's method is applicable.

especially electrical ones, are only too often out of order or away being repaired. For this reason an alternative method is given employ *dry* abdominal packs to absorb such of the fluid that is accessible without disturbing the viscera or disturbing them as little as possible. On no account cleanse the peritoneal cavity with packs wrung out in warm saline solution. If this is done not only will the delicate peritoneal coat become abraded but infection will be distributed, particularly to the subdiaphragmatic region.

Drainage.—Except in cases of under 12 hours duration without gross peritoneal contamination, I think it is wise to drain the peritoneal cavity. A suprapubic drainage tube can be placed easily by passing the left hand through the upper abdominal incision and inserting the tube as shown in *Figs.* 236, 237 p. 187

Excellent results have been published where the abdomen has been closed without drainage, but nothing is gained by omitting to place a drainage tube in the rectovesical pouch. The argument in favour of drainage is that as we do not know what was in the stomach before the perforation occurred it is advisable to drain the peritoneal cavity even in comparatively early cases, when the stomach was full at the time of the perforation

2. *The free omental graft patching the perforation* Closure of an indurated perforated lesser-curve ulcer is sometimes unsatisfactory for the sutures tend to cut out. It is in such a case that a free omental graft to reinforce the suture line is indicated. Spread the free edge of the greater omentum upon the towel covering the abdomen, and select a suitable portion. By cutting between hæmostats remove a piece about the size of four postage stamps. The technique of carrying this out neatly and expeditiously is to apply two long hæmostats close together taking a large bite of the free edge of the omentum and, at a point an inch or one-and-a half inches away to repeat the procedure. With scissors the omentum is divided between each pair of hæmostats. The medial two are then lifted up and the attached pedicle of omentum is grasped in the jaws of a fifth hæmostat (*Fig* 359) The omental graft is cut free, and we have in our possession the piece of patching material grasped between two hæmostats as is shown in *Fig* 360. The graft is wrapped in a moist pack while transfixion ligatures are applied to the stump of omentum grasped in each of the three attached hæmostats. The greater omentum requires secure ligation. The detached piece of omentum is ready for transfer and if it is kept taut between the hæmostats they function as spreaders until the graft has been sutured into place. If the graft is not handled in this way omentum tends to curl up and bungling with concomitant loss of time, will assuredly follow

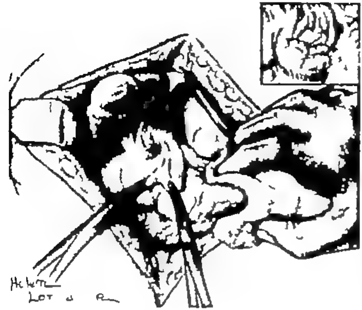

Fig 358.—Reinforcing a sutured perforated duodenal ulcer with a tag of the gastro-hepatic omentum.

3. *Utilizing the falciform ligament Fontana's method.* When the round ligament has been divided between hæmostats inferiorly and the associated falciform ligament has been freed from its attachment to the abdominal wall (*Fig* 361) both the stumps attached to the abdominal wall will require ligation, for they contain blood vessels. There is now available a hinged, triangular (base downwards) piece of patching material possessing admirable qualities. It can be swung over to patch a sutured perforation in any part of the area shown in *Fig* 361 Inset. It is particularly valuable for reinforcing sutured perforations in the neighbourhood of the lesser curvature of the stomach, for so often friability in this area renders a perforation difficult to close securely

Fig 359.—Showing the disposition of the five hæmostats. The graft is removed by cutting between Nos. 1 and 2, and between 3 and 4. Lifting up 2 and 3, No. 5 is applied, and finally the graft is freed by cutting along the dotted line.

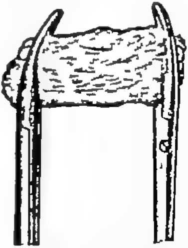

Fig 360.—Free omental graft. Method of transferring the graft.

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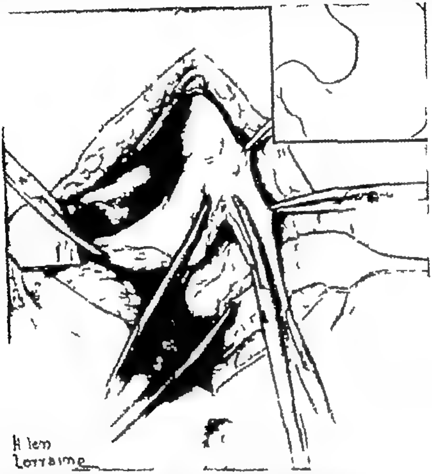

Fig. 241.—Fontana's method. Showing the round and falciform ligaments freed from their attachment inferiorly and laterally and ready to be utilized for patching a sutured perforated lesser curve ulcer Inset shows the area of the stomach where Fontana's method is applicable.

especially electrical ones, are only too often out of order or away being repaired. For this reason an alternative method is given employ *dry* abdominal packs to absorb such of the fluid that is accessible without disturbing the viscera, or disturbing them as little as possible. On no account cleanse the peritoneal cavity with packs wrung out in warm saline solution. If this is done not only will the delicate peritoneal coat become abraded but infection will be distributed, particularly to the subdiaphragmatic region.

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I have seen at necropsy a case operated upon three hours after perforation where drainage had been omitted—death was due to peritonitis. On at least six occasions I have been called to see patients with a pelvic abscess where the perforation was closed without draining the peritoneal cavity, moreover perforated peptic ulcer is the commonest cause of subdiaphragmatic abscess.

Following the repair of a perforated peptic ulcer a drainage tube left in position for not more than 48 hours cannot do any harm, and is sometimes instrumental in saving the patient's life. For late cases of perforated duodenal ulcer a second tube in the musculature of the right flank, designed to drain Rutherford Morison's pouch, is advisable.

Sump drainage (*see* p 169) of the rectovesical pouch is most efficacious.

SPECIAL CASES AND METHODS OF DEALING WITH THEM

The Diagnosis is Doubtful (? Appendicitis, ? Perforated Duodenal Ulcer).—Occasionally it is well-nigh impossible to be certain whether the case is one of a perforated duodenal ulcer leaking into the right iliac fossa (via Moynihan's gutter—*Fig* 362) or acute appendicitis. When this doubt exists it is a good practice to make a small gridiron incision. If the fluid in the peritoneum is odourless and the appendix is unperforated, the latter is

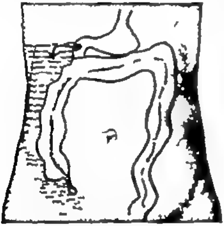

Fig 362.— Moynihan's gutter, which explains how the symptoms and *signs of perforated duodenal ulcer may* be referred to the right iliac fossa.

Fig. 363.—The appendix is not culpable. Ascertaining if there is fluid in the upper abdomen.

obviously not the source of the trouble, and the appendix is removed, the gridiron incision closed, and the upper abdomen opened. It should be noted that the appendix often looks a little inflamed when it has been bathed in duodenal contents. If there is purulent fluid in the peritoneum, and the inflamed appendix is unperforated, get someone in the theatre to slit up the appendix.

If the appendix is the source of the trouble it will surely be more pathological on the inside than on the outside (see Fig 293, p 229) if not, this organ is blameless. Search elsewhere. On more than one occasion I have derived help from passing up a swab on a holder towards the duodenum and leaving it in situ for a moment or two (*Fig* 363). Obviously if on removal the swab is soaked with non-odorous fluid it is imperative that the upper abdomen be explored.

"Dry" Perforated Peptic Ulcer.—By this is meant that perforation of the stomach or duodenum has occurred, but the stomach is empty or what is more usual, the perforation *is sealed by a tag of omentum or the fundus of the gall-bladder These cases are not quite* so difficult to diagnose as the foregoing group; indeed the condition is sufficiently common for a diagnosis of "dry" perforation to be made with some confidence, in which case the advisability of aspiration treatment (see p 281) may be considered.

The Perforation cannot be located easily; Searching for an Elusive Perforation.—When the perforation cannot be located by the measures described on page 272, the following plan is bound to lead to the discovery of a perforated peptic ulcer (*Fig* 364) if such be present.

1 Place a retractor in the right side of the wound and hand it to an assistant. While the parietes are retracted to the right and the stomach is drawn to the left, after extravasated fluid has been removed from the right kidney pouch the first and second parts of the duodenum can be inspected thoroughly thereby enabling the operator to be certain whether or not this portion of the ulcer bearing area is culpable. In one of my cases these expedients brought to light a perforation at the junction of the second and third parts of the duodenum—a most unusual situation.

2. After a non-productive search of the pyloric antrum and the duodenum, instruct the assistant to release his hold of the stomach and to place his retractor on the *left* lip of the wound. Proceed to examine the lesser curvature between the fingers and thumb palpate the lesser curvature right up to the œsophageal orifice. There is never any difficulty in recognizing immediately the massive induration around the edges of a perforated *gastric* ulcer

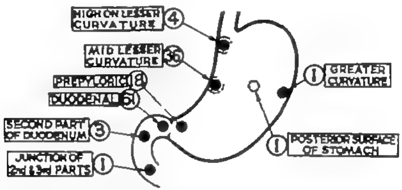

Fig 284.—Location of perforated peptic ulcers in a series of 125 consecutive cases operated upon by the author In a number of instances it was difficult to be sure on which side of the pylorus the perforation had occurred, consequently a few pre-pyloric ulcers may have been listed as duodenal ones. All the lesser curve ulcers were characterized by surrounding induration. Three examples of perforated hour-glass stomach are included in the mid lesser-curve group.

3. When the search along the lesser curvature proves fruitless, an opening is made in the omentum between the stomach and the colon. This permits an examination of the posterior surface of the stomach. When the lesser sac is found to be filled with gastric fluid, assuredly a perforation will be found somewhere on the posterior surface of the stomach.

A Perforation cannot be found in the Stomach or Duodenum.—Sooner or later the surgeon will be confronted with a case where he opens the upper abdomen in confident expectation of finding a perforated peptic ulcer Fluid is present, but a perforation cannot be found. Once a systematic search has been conducted in the manner detailed above, do not waste time by going over the ground again. Proceed as follows the physical characteristics of the fluid will sometimes lead to a short cut of the full programme.

1 Examine the gall-bladder

2. Consider the possibility of acute pancreatitis and make the relevant examination (*see* p 333). Sometimes there is a prodigious outpouring of free fluid in this condition, and the fluid is not necessarily blood-stained. It is never milky (opaque semi-purulent) or bile-stained.

3. Examine the jejunal mesentery for suppurating mesenteric lymph-nodes or a ruptured mesenteric cyst. In this connexion a ruptured intraperitoneal hydatid cyst is worth bearing in mind. A perforated primary jejunal ulcer is another possibility it is extremely rare.

4. Suitably cover the upper laparotomy wound and make a gridiron incision in the right iliac fossa Examine the appendix. If in real doubt as to its culpability remove it and have it slit up (*see* p 222). In other circumstances proceed to examine the last 2 ft. (60 cm.) of the small intestine for the presence of a perforated Meckel's diverticulum. On two occasions, while examining the lower ileum, I have come across a perforated ulcer of the ileum itself. In both cases the cause of the perforation remained obscure it was due neither to typhoid nor to tuberculosis.

5. On one occasion I had reached this stage without finding the causative lesion. There was a quantity of odourless fluid in the peritoneum. The patient was a muscular

man in his thirties. As a last resort a swab on a holder was passed through the grid incision towards the pelvic colon. On removing it the swab was malodorous. A t incision was therefore made in the left iliac fossa, and a perforated diverticulum of pelvic colon was revealed.

If nothing can be found to account for the profuse odourless peritoneal exud the only course is to insert a suprapubic drainage tube close the incisions and rely on a biotic therapy At what stage of the proceedings this is done must rest with the ju ment of the surgeon. It is highly desirable to collect some of the fluid for bacteriolog investigation.

Friable Gaping Perforations.—An expedient which considerably minimizes sut cutting out is to instruct the assistant to relax traction (but *not* his hold) upon the stom after each suture has been inserted. the stomach and duodenum fall b the suture is tied—if necessary blin At the appropriate moment the as tant renews his traction on the stoma and the result of the surgeon's ha work is displayed

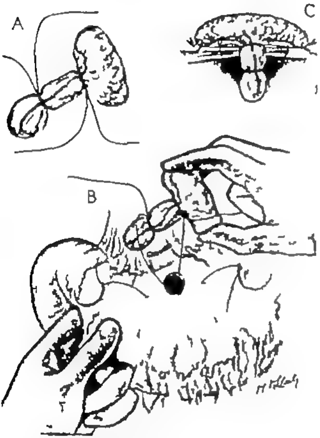

Fig 365.—A, Method of constructing an omental plug; B, Method of fixing the plug into the perforation; C, The plug operation completed.

From time to time examples encountered where the environs of perforation are so friable and und mined that attempts at closure, e by the above method, result in a la gaping hole

In such circumstances water-ti closure by the standard method is i possible or risky and resort must *made to one of the following expedien*

The omental plug is suited parti larly to *gastric* perforations belong to this category A free omental gr *of suitable dimensions is cut, erring* the side of liberality The graft rolled and fashioned into a dumb-b one end being considerably larger th the other Such a plug is easily co structed by tying two sutures arou its waist the ends of these are l long (*Fig* 365, A) One end of each these sutures is passed, via the p foration, through the stomach w beyond the friable area (*Fig* 365, The smaller end of the dumb-bell pushed through the perforation. Ea suture is tied to its fellow quite lightly so as to avoid cutting out. *The only object of th* sutures is to anchor the plug for the next step, which is most important. The large end the dumb-bell is attached to healthy stomach wall by interrupted sutures all around periphery (*Fig* 365 C).

Gatch and Owen's method is suited only to juxtapyloric duodenal perforations, a relative common site for large friable, gaping perforations. To employ this method in ca belonging to, or bordering upon, this category would prevent a number of cases of su diaphragmatic abscess. Several sutures are inserted as shown in *Fig* 366 A. They a not tied until they have all been placed. It will be noted that on the one hand the stoma wall is traversed 1½–2 in. (3·8–5 cm.) proximal to the pylorus, while on the other the sutur pick up indubitably healthy duodenum. If possible the first (uppermost) stitch catch the gastro-hepatic omentum, so when this stitch is tied the latter structure reinforces t roof The remainder of the stitches, when tied, draw the anterior surface of the stoma over the perforation and close it without tension upon the *sutures* (*Fig* 366 B). Th suture line is strengthened where necessary by additional stitches and then covere

completely by an omental graft. Contrary to what might be thought, this procedure does not obstruct the duodenum, and there is no necessity to perform gastrojejunostomy on this account.

Inaccessible Ulcer High on the Lesser Curvature.—Exceptionally cicatrization of the gastro-hepatic omentum has so fixed the stomach that it cannot be drawn down. In these circumstances in order to get more direct access to the ulcer it may be advisable to excise some of the left cartilaginous costal margin, which is readily removed with a scalpel. This is infinitely preferable to pulling on the stomach unduly

A B

Fig. 346.—Gatch and Owen's method of closing a friable gaping perforation on the duodenal side of the pylorus. A, Shows how the sutures should be placed. All should be inserted before they are tied. B, Shows the perforation closed by this method. A free omental graft completes the operation.

Perforated Hour-glass Stomach.—The ulcer which gives way is saddle-shaped and the perforation is a large one situated in a narrow isthmus. It thus comes about that the stomach may be almost in two halves. This is what was found in three of my early cases. Each was treated by simple suture reinforced by an omental graft. In each instance death occurred from hæmatemesis or internal hæmorrhage about the fourteenth day in spite of blood transfusion. Undoubtedly the correct treatment for this condition is to perform partial gastrectomy All that is necessary is to complete the bisection of the stomach, trim the proximal torn edge of the stomach, and in so doing excise the scar tissue remove the distal end, and close the duodenal stump The proximal end of the stomach is then anastomosed to the side of a loop of jejunum brought up in front of the transverse colon.

Pseudo-perforated Ulcer.—Occasionally cases are encountered which present many if not all, of the characteristics of a perforated gastric ulcer yet on laparotomy nothing is found. The gastric crisis of tabes, of course is a well known trap but this is so familiar that I venture to think this error is very seldom made at the present time. In this connexion it is interesting to refer to *Case 75* of my series. This patient had both tabes dorsalis and a perforated duodenal ulcer The diagnosis of perforation was clinched by the elicitation of shifting dullness.

An acute exacerbation of symptoms of chronic gastric ulcer may simulate a perforation of that ulcer Usually rigidity is localized, but occasionally it is not possible to be certain if the ulcer has perforated or not. If doubt exists, laparotomy should be performed.

W C., aged 40, gave a typical gastric ulcer history extending over 5 years. At 6 p.m. he was seized with agonizing abdominal pain, and his doctor sent him to hospital at 10.30 p.m. with the diagnosis of perforation.

He presented a classical picture of perforated peptic ulcer as regards board-like rigidity There was one extraordinary feature of the case—the agonizing pain came in spasms, and radiated down the arms to the finger-tips. He had two such spasms whilst being examined. Wishing to exclude the possibility of a cardiac lesion I asked my medical colleague to see him. As the heart and lungs were found to be normal laparotomy was undertaken. A large angry pyloric ulcer was found, but no perforation. Posterior gastro-jejunostomy was performed. Recovery and relief followed.

Re-perforation is rare. As shown by massed statistics, it occurs in 1–2 per cent of cases that have been treated by suture, or expectantly That re-perforation is allowed

to occur is, in most instances, a reflection on the follow-up system that should always be inaugurated. Re-perforation usually takes place at the site of the first perforation.

Perigastric Abscess is an uncommon condition that usually arises in one of two ways (1) The amount of fluid escaping from a leaking duodenal ulcer due to a minute perforation may be small enough to be confined to Morison's right kidney pouch, and there become shut off from the rest of the peritoneal cavity by adhesions (2) An ulcer on the posterior wall of the stomach perforates into the lesser sac, the foramen of Winslow being occluded by adhesions.

Some days after an acute attack of upper abdominal pain a tender swelling appears in the epigastrium or right hypochondrium. Usually the temperature is elevated.

Treatment.—If on laparotomy an abscess of the first variety is found, it is best to drain it through a counter incision in the flank. An abscess of the lesser sac can be drained conveniently through the gastrohepatic omentum. An unavoidable complication that is prone to occur is the development of a gastric or duodenal fistula (*see* p. 529).

Perforated Gastrojejunal Ulcer.—Here simple suture with reinforcement by an omental graft is indicated. A jejunostomy (*see* p. 523) can be added with advantage in most cases. The patient can be fed through the jejunostomy thereby giving the ulcer a chance to heal, but in most instances further surgical treatment will be necessary when the patient's condition allows. Usually at least two or three months should elapse before such treatment is undertaken.

Perforation of an Inflamed Duodenal Diverticulum (*G P B Huddy's Case*).—A married woman, aged 27 complained of epigastric pain. On the following day the pain became more acute and she vomited four times. On examination the temperature was 101.5 F (38° C.) and there was rigidity and tenderness over the upper part of the right rectus muscle A diagnosis of acute appendicitis, with the appendix under the right lobe of the liver was made.

On opening the abdomen by a paramedian incision the appendix was found to be normal. This was removed. Flakes of lymph were seen on the peritoneum in the upper part of the wound and a lump was palpable in front of the right kidney The skin incision was prolonged upwards, and an incision made through the peritoneum on the outer side of the second part of the duodenum. It was then possible to isolate a pouch connected with this part of the duodenum. The pouch had a diameter of an inch, was thin walled, and black in the centre. The diverticulum was excised, and the base closed. It was found impossible to invaginate the suture line satisfactorily The friable peritoneum was approximated as well as possible, and a stab drain inserted.

On the third day after operation duodenal contents began to pour out of the stab drain. This gradually ceased, and the stab wound closed on the 17th day Recovery

Perforated Carcinoma of the Stomach.—In approximately 40 per cent of cases, by the time a carcinoma of the stomach has perforated, metastases are present. Ten per cent of apparently simple *gastric* ulcers that perforate prove later to be cases of carcinoma (*see* pp. 281 283). If the perforated ulcer is considered to be carcinomatous, and the patient is in fair condition, if the operator is experienced in its performance, this is an indication for partial gastrectomy provided no more than a subtotal gastrectomy is required. Should a more extensive operation be required, or if the operator is not a practised gastrectomist, closure of the perforation should be undertaken. The friable edges of the perforation will almost certainly be difficult or impossible to approximate and recourse must be made to omental plugging described already

AFTER TREATMENT OF CASES OF PERFORATED PEPTIC ULCER

Careful after treatment will forestall many complications. If the pulse is satisfactory the patient is propped gradually into Fowler's position unless he finds the position uncomfortable, which is unusual.

Post-operative gastric suction should be maintained until the abdominal wall becomes flaccid, and the patient has passed flatus this usually occurs between the third and the fifth post-operative days. Penicillin, 500,000 units, and streptomycin 0·5 G., are given intramuscularly 12 hourly for seven days. Fluid is given parenterally for three days, or until such a time that the necessity for gastric aspiration has ceased, and it has been proved that coloured barley water passes onwards through the pylorus (gastric motility test (*see* p. 107)). Milk feeds can then be commenced. A day or two later a light gastric diet is given, with gradual return to a full normal diet.

Special Nursing Instructions.—The suprapubic tube is to be shortened and turned 48 *hours after operation, and removed at 72 hours.*

If the patient vomits stop all feeds.

In the event of vomiting a gastric aspiration tube must be re-inserted with as little delay as possible.

The Prevention of Complications.—If special precautions are taken the incidence of chest complications, so lethal in these cases, can be reduced. Regular breathing exercises, inhalations of CO_2 for the first four days, and early ambulation are all most valuable but unless the surgeon insists it is unlikely they will be carried out as a routine. Another point to bear in mind is that many of these patients are suffering from vitamin-C (ascorbic acid) deficiency which is seriously detrimental to wound healing. Vitamin C must be administered in some form or other as soon as the immediate crisis is over.

Unless the surgeon is satisfied that the patient is not anæmic, a hæmoglobin estimation should be carried out during the first few days after the operation. In minor degrees of anæmia ferrivenin is sufficient to restore the hæmoglobin level to normal. When the hæmoglobin is low blood transfusion will do much to hasten recovery. Especially in patients between 50 and 60 years of age who have undergone successful suture of a perforated peptic ulcer it is most necessary to be *on the look-out for melæna during the post-operative period.*

Causes of Death following Operations for Perforated Peptic Ulcer.—It is a mistake to be too gloomy where the hours since perforation have reached double figures. Nearly 40 per cent of my patients had perforated more than twelve hours before they were admitted, while in 16 per cent over twenty hours had elapsed. Ten out of 19 in the last group died.

Infrequently, even in comparatively fit subjects, death from shock occurs within two hours of perforation. As evinced by the comparatively slow pulse-rate, shock is usually not a notable feature of perforated peptic ulcer. The principal cause of death is peritonitis. Pneumonia and other complications of the lungs are second; not far behind comes bleeding from a sutured ulcer within three weeks of the perforation. Subdiaphragmatic abscess and pulmonary embolism account for a much smaller proportion of the fatalities.

Age (mortality increases greatly over 60 years of age) and delay between the moment of perforation and the commencement of treatment remain the most important factors in prognosis. The mortality of perforated gastric ulcer is twice that of perforated duodenal ulcer. To this must be added late deaths from carcinoma of the stomach in cases of perforated gastric ulcer. Avery Jones and Doll found that in 10 per cent of cases of perforated gastric ulcer the patient had died of carcinoma of the stomach from between 18 months and 12 years after successful suture of the perforation.

Mortality Statistics.—Many recent series of cases showing very low mortality figures emanate from hospitals serving a crowded, but limited, industrial area; thus the patients live near the hospital, and their doctors have comparatively little difficulty in obtaining prompt acceptance for admission of their patients. Furthermore delays in transportation are reduced to a minimum.

In this chapter the surgeon who has to deal with a comparatively unfavourable type of patient and under conditions which are not ideal has been catered for. The methods I have set out have been designed to override difficulties, and if success follows how much more certain will be the outcome in more favourable circumstances?

OTHER METHODS OF TREATING PERFORATED PEPTIC ULCERS

Non-operative Treatment.—Hermon Taylor prefers to call the method *the aspiration treatment of perforated peptic ulcer.* It has been the subject of many recent papers and much controversy. A few surgeons enthusiastically commend it as a method suitable for general adoption, but the majority consider that its dangers considerably outweigh its advantages.

Details of the Method.—

1. *The Pulse and Temperature Charts* are similar to those for the Ochsner-Sherren treatment of appendicitis (see p. 232).

2. *Repeated Radiographs* must be looked upon as an essential part of the aspiration treatment. In the first place without their aid it is impossible to be certain that the tip of the gastric aspiration tube is well within the stomach. Secondly, an initial radiograph and one repeated 12 hours after admission will show the tell-tale layer of air beneath the diaphragm. If the perforation becomes sealed by fibrinous lymph this subdiaphragmatic shadow slowly diminishes in size. Conversely, if the shadow has increased in size after

the passage of a stomach tube the size of an index finger to allow air in the stomach and peritoneal cavity to escape operation should be performed without further delay

3. *Gastric Aspiration* should be done *only by hand.* An electric suction pump, Wangensteen's apparatus, and other mechanical devices can never replace a special nurse. At any time a gastric aspiration tube is liable to become blocked, and requires human attention immediately without such attention the patient's life is in jeopardy The actual point in question is not that intermittent aspiration is more effective than continuous, but rather by which method will the fact that the aspiration tube has become ineffective as a result of blockage or displacement of the tube be discovered first? Undoubtedly the need to return every fifteen minutes to the patient, in order to undertake intermittent aspiration, ensures more frequent clinical observation of the patient's condition.

4 *Fluid Balance* must be adjusted accurately

First twenty-four hours Aspiration every fifteen minutes. Three pints (1 7 L) of fluid parenterally plus the amount of fluid aspirated.

Second twenty-four hours Aspiration every half hour followed by a drink of one ounce (30 mL) of water

Third twenty-four hours Aspiration every hour but a mixture of milk and water instead of water only

On the fourth day the tube is removed if the fluid chart proves that all the fluid taken by mouth is indubitably passing onwards.

5 *Drugs* Having decided on non-operative treatment, the patient should receive not more than ⅙ gr morphine (10 mg) subcutaneously If he does not experience considerable relief of pain after 6 hours of gastric aspiration, a second radiograph is taken with a portable machine, and a consultation is held questioning the diagnosis. *Only in the most exceptional circumstances is even a second dose of morphine prescribed.*

6. *Antibiotic Treatment.* Penicillin, 500 000 units and streptomycin, 0·5 G. are given intramuscularly 12 hourly

Indications and Contra indications.—As yet there is no conclusive evidence that treatment by aspiration, which is practised much less frequently than operative treatment, has effected a lowering of the mortality even when the desirable nursing facilities are of a high order The method is contra-indicated in the presence of bleeding or pyloric stenosis, after a heavy meal and in air swallowers. It should be noted especially that air swallowers can swallow air faster than it can be aspirated for them, gastric aspiration treatment *is forbidden* absolutely Undoubtedly it is the method of choice in cases of dry perforation (see p. 276) and in patients with a cardiac lesion, emphysema, or some other condition which renders operation dangerous. It is also indicated when facilities for operation are practically non-existent (e.g a small ship at sea).

N B *Aspiration treatment is nearly always fatal in patients severely ill with diffuse peritonitis.* Therefore it must not be used in the very type of case that on a prima facie acquaintance with the subject one would think is more suitable for non-operative treatment than almost any other

Disadvantages and Dangers of Aspiration Treatment.—

1 One cannot judge, without operation, whether the peritoneal contamination is, or is *not, excessive.* Even if the stomach is kept empty peritoneal contamination can occur from regurgitation from the duodenum and the ileum.

2. A perforated carcinoma cannot be diagnosed.

3. There is a risk of leaving unoperated another condition requiring operation.

4. The incidence of lung complications is higher than with operative methods, as also is the occurrence of intraperitoneal and subdiaphragmatic abscesses.

Iselin considers that if the pain has not gone within three hours of conservative treatment the diagnosis and the treatment should be questioned. An increasing pulse-rate or failure of the pulse-rate to diminish are also reasons for abandoning conservative treatment.

Non-operative treatment demands frequent repeated expert clinical and radiological assessment, and an error in gastric aspiration, or transient relaxation of vigilant nursing observation may be followed by a disaster The method is safe only in the hands of a surgeon trained in the method, who has at his disposal ample medical radiological, and nursing assistance. Definitely it is unsuitable for routine use.

Additional Gastrojejunostomy.—All the benefits of keeping the stomach empty can be achieved by a gastric aspiration tube in the early post-operative period. *The only indication*

for a gastrojejunostomy is the presence of obvious obstruction due to cicatricial stenosis; œdema does not fall into this category.

Immediate Partial Gastrectomy for Perforated Peptic Ulcer is performed in a high percentage of cases in some well-equipped hospitals. The possibility of a perforated *gastric* ulcer proving to be carcinomatous, the facts that the mortality from a hæmatemesis and melæna following suture of a perforation is greater than is commonly supposed, and that partial gastrectomy is easier to perform at the time of operation for the perforation than at a second operation, are the main arguments put forward by protagonists of the method. For its successful performance:—

1. The surgeon must be experienced in gastrectomy.
2. The case should be an early one (under 10 hours' duration).
3. The patient must be in a fit condition to withstand a severe operation.

However, in most clinics the indications are limited to:—

1. When bleeding has preceded the perforation.
2. When the ulcer is believed to be carcinomatous, and a partial gastrectomy may cure the patient of the neoplasm.
3. Perforated hour-glass stomach.

Obesity, abdominal distension, œdema of the duodenum (difficulty in closure of the duodenal stump) are among the less obvious contra-indications to this formidable operation.

Approximately 10 per cent of patients with partial gastrectomy will suffer from one or other of the post-gastrectomy syndromes. As 30 per cent of patients with perforated ulcer simply closed suffer no further ulcer symptoms, why burden them with a 10 per cent chance of having disabling post-gastrectomy syndromes?

END RESULTS

As might be expected, after both suture and aspiration treatment there is a transient remission of symptoms due to the rest in bed and the careful dietetic supervision during convalescence. Elderly patients and those of any age with a short dyspeptic history are the ones who are likely to remain symptom-free after successful treatment of a perforation (Illingworth). Nevertheless, within one year 40 per cent of patients relapse, and within five years 70 per cent. On this account the surgeon should warn those who have been fortunate enough to survive perforation to report, so that, if necessary, they may receive timely treatment for an active ulcer. Many require medical supervision for years, and in at least 50 per cent of cases further surgical treatment is indicated.

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CHAPTER XXIII

HÆMATEMESIS AND MELÆNA

IN about 95 per cent of cases of hæmatemesis and melæna the bleeding comes from a gastric or a duodenal ulcer The ulcer in question can be either acute or chronic, but in two-thirds of these cases it is a chronic ulcer that is responsible.

Chronic Bleeding Gastric Ulcer is commonly situated on the posterior wall of the stomach towards the lesser curvature. Such an ulcer is often adherent to, or has penetrated, the pancreas or the liver and the bleeding occurs from a comparatively large vessel in the floor of the crater (*Fig* 367) In rare instances the splenic artery is eroded.

Chronic Bleeding Duodenal Ulcer is nearly always situated on the posterior wall of the first part of the duodenum. Frequently the bleeding comes from a large branch of the gastroduodenal artery on rarer occasions from the gastroduodenal artery itself.

Fig 367.—The open mouth of a bleeding artery can be seen at the bottom of this ulcer crater In such a case how can conservative measures do more than tide the patient over a hæmorrhagic crisis? (*Collinson and Stewart, British Journal of Surgery*)

A chronic duodenal ulcer is the cause of serious hæmorrhage five times more frequently than a chronic gastric ulcer

Acute Bleeding Ulcer occurs most often in the distal half of the stomach, but the proximal half of the stomach and the duodenum are not immune. Two or more ulcers are sometimes present. Acute ulcers involve the mucosa only they are impalpable externally and even if the stomach is opened, they are difficult or impossible to feel among the innumerable folds of mucous membrane. In not a few cases there is no real ulcer present, but multiple minute erosions causing the whole stomach to weep (blood gastrostaxis) Although true acute ulcers can be seen gastroscopically they do not show radiologically In the majority of cases patients with acute bleeding lesions of the stomach suffer little or no pain or discomfort, either before or after the bleeding occurs. One-third of all cases of hæmatemesis and melæna are proved eventually to be caused by acute lesions.

Notwithstanding the comparative insignificance of the blood vessels involved, hæmorrhage from an acute ulcer in spite of conservative treatment including blood transfusion, can on occasions prove relentless. The mortality of bleeding gastric ulcer (mostly chronic cases) is about twice that of bleeding duodenal ulcer Speaking generally hæmatemesis carries a worse prognosis than melæna alone (Crohn and Janovitz)

In cases where portal hypertension is suspected, the bromsulphthalein test gives valuable diagnostic confirmation. Retention of 17 to 60 per cent of the dye favours hepatic cirrhosis (Zamcheck et al.), but the most reliable method is to perform œsophagoscopy and visualize the bleeding varices.

Onset.—Referring to peptic ulcers, and in particular to chronic peptic ulcer quite often the bleeding comes on during a quiescent period of the ulcer the patient having been free from symptoms for weeks or months. Conversely if the patient has been experiencing pain prior to the hæmorrhage, as a rule, when the bleeding commences the pain passes off, due, it is thought, to relief of congestion. On the *other hand,* if pain continues there seems to be a special tendency to further hæmorrhage.

Serious hæmorrhage from a *gastric* ulcer is ushered in by collapse and pallor followed by hæmatemesis, which is effortless vomiting of coffee-ground material, sometimes followed by bright-red blood. When severe hæmorrhage takes place from a *duodenal* ulcer the

patient says he feels faint. This is followed by the passage of a melæna stool. So great may be the bleeding that bright red clotted blood is passed per rectum.

COMPARATIVELY RARE CAUSES OF SEVERE GASTRO-INTESTINAL HÆMORRHAGE

AVENUE	CAUSE OF HÆMORRHAGE	CLINICAL DIAGNOSTIC AID	
1. Mainly hæmatemesis	Stomal ulcer	—	
2. Mainly hæmatemesis	Portal hypertension (œsophageal varices)	Spleen and liver enlarged. Spider nævi. Caput Medusæ	*See* p. 743
3. Blood per rectum	Bleeding Meckel's diverticulum	When the patient is a child, diagnosis not difficult	*See* p. [illegible]
4. Hæmatemesis and melæna	Bleeding jejunal diverticulum (*See Fig.* 348)	—	
5. Blood per rectum	Bleeding colonic diverticulitis	Blood bright red	*See* p. 235
6. Blood per rectum	Purpura with intestinal symptoms	Flea-bites on skin and sometimes bruising	*See* p. 491
7. Blood per rectum; occasionally hæmatemesis	Mesenteric vascular occlusion	Abdominal pain considerable	*See* p. 459
8. Hæmatemesis and/or melæna	Hereditary telangiectasis	*Usually history of* recurrent epistaxis	*See Chapter* XC
9. *Hæmatemesis* or melæna	Gastric or intestinal neoplasm	—	
10. Blood per rectum	Solitary peptic ulcer of the small intestine	—	
11. Melæna	Appendicectomy	—	*See* p. [illegible]
12. Hæmatemesis	Idiosyncrasy to aspirin	—	

Even when a large vessel is eroded, death seldom results from the initial hæmorrhage. Far more frequently a large hæmorrhage is heralded by two or three smaller ones on consecutive days, as in other cases of secondary hæmorrhage. Soon after the initial bleeding the presence of sweating, as well as anæmic pallor (as shown in the palms of the hands and the palpebral conjunctivæ), are more valuable indications of a considerable loss of blood than the pulse-rate. Conversely, after the first hour of treatment quickening of the half-hourly pulse-rate is the best single sign of renewed bleeding.

When loss of blood is sufficiently rapid to produce signs of peripheral hypotension (shock) or necessitate the administration of 2½ pints (1500 ml.) or more of blood in 24 hours, by convention the hæmorrhage is said to be massive.

Management.—The patient having been put to bed, if the pulse is weak and rapid, the foot of the bed is raised; otherwise he is laid flat with one pillow beneath his head. He is kept warm, but not heated artificially in any way. The pulse-rate and blood-pressure are taken, and orders are given that the pulse be recorded every half hour, and that any noticeable change in it is a signal for a further estimation of the blood-pressure. Five ml. of blood must be aspirated from a vein for an initial hæmoglobin estimation, blood-grouping tests (including Rhesus testing), a blood-urea estimation, and for serum for direct testing. This is followed by the slow intravenous injection of ¼ gr. morphine.

Gastric Lavage plus Adrenaline and Stypven.—The most successful time for the use of adrenaline and stypven is immediately after the bleeding has taken place. A gastric aspiration tube is passed, and the stomach is irrigated with 1 pint (568 ml.) of sterile water. Twenty ml. of adrenaline hydrochloride (1–1000 solution) is injected down the tube, and the tube is left in situ. After 20 minutes gastric lavage is repeated, and a further 20 ml. of adrenaline is injected, followed a few minutes later by 5 ml. of stypven.[1] In order to ensure that none of the stypven remains in the tube [illegible] ml. of sterile water is injected. It is probably safer to leave the gastric aspiration tube in place and to aspirate at intervals, in order to detect fresh hæmorrhage.

[1] Stypven (Burroughs Wellcome & Co.) Russell Viper venom.

Sometimes the stomach is full of clots, and lavage will not remove these. Occasionally the initial dose of adrenaline acts as a mild emetic should it not do so the interval between the first and second gastric irrigations permits the bulk of the clot to be evacuated through a patent pylorus. A second lavage then removes most of the remainder Acute gastro-duodenal lesions stop bleeding immediately after the administration of adrenaline and stypven adequate transfusion then nearly always ensures an uneventful recovery A high proportion of chronic gastroduodenal lesions respond in the same way (Brandon)

After the gastric lavage usually the patient should be permitted to have an hour's rest. During this time relatives are interviewed and particulars of the onset and previous history are obtained. The opportunity is taken to enlist their services as possible blood donors.

Revisited, if the patient is fit to be interrogated without undue fatigue, a careful unhurried history is taken, for on this much reliance must be placed.

Physical Examination.—To ascertain if the diaphragm is moving, gentle palpation for tenderness and rigidity (to exclude a concomitant perforated peptic ulcer or acute appendicitis) are a *sine qua non* but deep palpation for a lump in the epigastrium should be eschewed at this early hour also detailed examination of the bases of the lungs, which can be postponed for hours as part of the designed plan to disturb a partially exsanguinated patient as little as possible None the less, the sign of Troisier should be sought, and information gained by rectal examination as to whether the rectum is loaded or the stools tarry is always of great value. If, at this second examination, increasing pallor beads of perspiration on the forehead, clammy hands, and especially quickening of the half hourly pulse-rate bespeak of a seriously depleted blood volume and that bleeding is probably progressing, taking the history and making a physical examination are abandoned *pro tem* in favour of transfusion as soon as matched blood is available.

Blood Transfusion is required in all cases of serious hæmatemesis and/or melæna. It is impossible to state how much blood will be needed to be provided with a pint of blood in reserve is a matter for considerable forethought and planning in outlying districts.

When, as a result of a dose of morphine, the patient has become tranquil in bed is the time to commence transfusion. The usual rate of the drip transfusion should be 60 drops per minute, the aim being to give one pint in four hours, but more rapid transfusion is required in cases of continued or renewed hæmorrhage. Usually it is sufficient to give two or three pints on one occasion, although this frequently needs repetition. It is essential to prevent the onset of anæmic anoxæmia, with its restlessness leading to irreversible shock. If bleeding has been severe, the risk of raising the intravenous pressure and precipitating acute heart failure by too rapid transfusion must be guarded against by watching the veins of the neck, especially the external jugular vein in the supraclavicular triangle

In a case of moderate severity after one pint has been given at the rate of 60 drops a minute slowing and steadying of the half-hourly pulse-rate and a decrease in pallor are signs that the blood is being retained in the circulation.

Frequent pulse-rate and blood pressure readings are continued for at least three days after apparent cessation of hæmorrhage The drip transfusion is continued at a rate of 30 drops per minute until the hæmoglobin level has reached at least 75 per cent. A serious depletion in the blood volume is more dangerous in the elderly because with depleted erythrocytes sufficient oxygen is not carried through the atheromatous coronary arterioles to the cardiac musculature therefore such patients, in addition to blood transfusion, should receive oxygen therapy

It should be noted that in cases of a low hæmoglobin estimation associated with an adequate blood pressure the administration of packed red cells is effective and carries much less risk of untoward reactions than massive transfusion of whole blood (*see below*)

In rare cases of catastrophic hæmorrhage intra-arterial transfusion of several pints is necessary to preserve life

Laboratory Aids in assessing how much blood will be required are as follows —

Hæmoglobin Estimation.—Very soon after a severe hæmorrhage the level of the hæmoglobin is often within normal limits,[1] and therefore no reliance should be placed upon it

[1] Estimation of blood volume or hæmatocrit gives more valuable information in early severe hæmorrhage

at this critical time. After three hours, estimations, repeated at frequent intervals, provide valuable information. *A hæmoglobin level of 60 per cent or under is an indication that the patient is in dire need of blood.*

Blood urea.—A rise in the blood-urea (70–100 mg. per 100 ml.) is so consistent as to be of some value as an index of the severity of the hæmorrhage. The probable explanation for the rise is a diminished flow of anoxæmic blood through the kidneys. A blood-urea of over 150 mg. is likely to be due to dehydration, chronic nephritis, or alkalosis. In all, extra fluid by mouth should be given.

Failure of Repeated Transfusions in Prolonged and Recurrent Hæmorrhage.—If operative treatment is withheld, especially in patients of the older age groups, in spite of, or because of, numerous transfusions, a stuporous state sometimes supervenes, accompanied by a high blood urea and a low output of urine. The cause of this condition is not known, but it is believed to be due to liver failure. When such a state ensues it is too late for surgical treatment, and the patient usually succumbs.

Diet.—Even the presence of active bleeding is not an occasion to starve the patient. *Within two hours of admission, feeding is commenced.* The majority of gastro-enterologists and surgeons recommend that until the bleeding has ceased, and for two days thereafter the diet should be entirely fluid. Especially in the weak and prostrated, and indeed almost as a routine, there is much to be said for giving the nourishment by the drip method (see p. 58) through an indwelling gastric tube with a diameter of 7 mm. A great advantage of this method is that the tube serves a dual purpose. Every two hours, day and night, 5–10 ml. of stomach contents are aspirated: the nurse reports at once if the fluid is blood-stained. Feeds consist of milk, eggs and milk, alternating with Benger's food and Ovaltine, together with vitamins: all must be diluted to flow freely. After 72 hours the tube is withdrawn, and if progress is satisfactory milky porridge is allowed.

Additional Fluid.—Thirst must be prevented entirely by allowing the patient to drink as much one-third normal saline flavoured with fruit juice as he pleases. It is of the utmost importance to stimulate the nursing staff to make sure that at least 3½ pints (2 L.) of this fluid is imbibed by the patient (or given in the intragastric drip) during the 24 hours, and that a fluid balance sheet is kept accurately. When pyloric stenosis is present some of the fluid must be given as dextrose-saline intravenously.

Drugs.—To keep the patient at rest, morphine may have to be repeated, but as soon as it is considered safe to do so, phenobarbitone 0·5–1·0 gr. two or three times a day to maintain mental relaxation, is substituted. Morphine is lethal to patients with emphysema: in such cases phenobarbitone should be prescribed instead. Ascorbic acid, 500 mg., is given daily. When progress is satisfactory it is desirable to give an antacid such as magnesium trisilicate or aludrox, 2 teaspoonfuls t.d.s. after meals. During convalescence iron is given in full doses.

Bowels, if they have not acted before, should be emptied on the fourth day with a glycerol suppository supplemented, if necessary, by a particularly gentle enema. To allow the patient to strain at stool must be rigorously circumvented by the nursing staff.

PERFORATION DURING, OR SOON AFTER, BLEEDING FROM A CHRONIC ULCER

Perforation during, or soon after, bleeding from a chronic ulcer occurred in 75 of 650 cases reported by Avery Jones. When perforation follows upon the heels of bleeding, it usually does so within 24 hours of the commencement of hæmatemesis or melæna. In such cases classical boardlike rigidity is often absent. If the condition of the patient seems more serious than would be expected from the bleeding, or if pain is a prominent feature, the possibility of concomitant perforation should receive full consideration.

BLEEDING AFTER PERFORATION

Serious bleeding after suture (or conservative treatment) usually occurs between the third and tenth days after admission. The association of bleeding and perforation usually indicates a double duodenal ulcer—the anterior ulcer perforating and the posterior ulcer bleeding—or a giant gastric ulcer. With these probabilities in mind operative, as opposed to conservative, treatment is definitely indicated.

OPERATIVE TREATMENT OF HÆMATEMESIS AND MELÆNA

Finsterer of Vienna, advised operation within 24 hours in all patients with a long history of peptic ulcer and in the absence of such a history when the bleeding continues or recurs in spite of transfusion. While subscribing to the latter injunction, the majority of surgeons, recognizing that conservative treatment is very often successful and that very few patients die of the initial hæmorrhage, pin their faith on conservative treatment, and operate only when non-operative treatment is unlikely to succeed.

INDICATIONS FOR URGENT OPERATION

1. If, after 6 and before 36 hours of conservative treatment there is one or more of the following (*a*) hæmatemesis (*b*) fainting followed by a severe melæna (*c*) a pulse-rate remaining over 90 in spite of transfusion (*d*) failure of the hæmoglobin to rise.

2. If at any time while conservative treatment is in progress bleeding which has stopped, starts again.

3. In exceptional circumstances so violent or persistent is the hæmorrhage that it is not advisable to proceed with the 24 hours trial of conservative treatment.

4. The presence of other complications of a chronic ulcer to wit, pyloric stenosis, hour-glass stomach, bleeding following perforation.

In doubtful cases the fact that the patient is over 50 years of age or that he has hardened radial arteries, weighs in favour of advising urgent operation.

The added risk due to the presence of unrelated disease such as emphysema, bronchitis, cardiac disease, or nephritis renders the risk greater than that of conservative treatment. Therefore the latter is chosen, unless the need for operation is imperative.

Ogilvie et al. point out that should the rate of respiration increase *pari passu* with that of the pulse, the cause is more likely to be cardiac failure or bronchopneumonia than renewed bleeding, particularly if increasing pallor is not in evidence.

Immediate Pre-operative Treatment.—It is essential to empty the stomach. Although it does not happen often, if the gastric aspiration tube becomes blocked with clot, a No. 11 rubber œsophageal tube is passed, of course, via the mouth, and the stomach is irrigated with normal saline solution. In all cases transfusion is continued throughout the operation, and for 24 hours afterwards.

LAPAROTOMY FOR BLEEDING PEPTIC ULCER

The Incision.—The abdomen is opened through a midline incision, unless it is known beforehand that a chronic duodenal ulcer is present, when a transverse incision over the right rectus is preferable, especially in obese patients.

Choice of Operation.—Unfortunately in many cases—particularly those due to acute ulceration—no operation simpler than subtotal gastrectomy will stop the hæmorrhage. Concerning the latter type of case, if the bleeding is of great severity and no lesion is found, gastrectomy is advisable because it removes four fifths of the erosive area and partially devascularizes the remainder (Tanner) The stomach in these cases is free from adhesions consequently the operation is straightforward. On the other hand, subtotal gastrectomy for an adherent callous ulcer while being unquestionably the most desirable procedure is likely to prove difficult, and when the patient is in poor condition and/or the surgeon lacks experience in this field one of the alternative procedures to be described should be chosen If the surgeon feels competent to carry out subtotal gastrectomy he should do so by the technique with which he is most familiar A description of the various methods of performing subtotal gastrectomy is beyond the scope of this book.

In performing subtotal gastrectomy should the bleeding ulcer be situated in the duodenum and is penetrating the pancreas, a common situation, it is better not to attempt to remove the ulcer and thereby risk injury to the common bile-duct or one of the pancreatic ducts. The duodenum should be divided obliquely proximal to the ulcer so as to obtain a rather longer anterior than a posterior duodenal wall. The mid-point of the anterior wall is seized with tenaculum forceps, thus displacing the ulcer Beneath the centre of the crater is placed a deep catgut stitch, and having filled the crater with a piece of gelfoam or oxycel, the stitch is tied, not tightly for fear of cutting out. The sides of the V created by traction of the anterior wall are approximated with interrupted stitches until the duodenal orifice is narrowed and the anterior part of the orifice formed by the duodenal

wall becomes equal in breadth to the posterior part bounded by the pancreas (*Fig* 368, a, b). What F H. Bentley describes as the pixie cap of the anterior wall is now turned into the lumen abutting the gelfoam, and secured by a thread suture, which takes a firm bite of the mid point of the proximal rim of the ulcer in the pancreas, and a seromuscular bite of the anterior duodenal wall at the base of the cap (*Fig* 368 c) A series of similar stitches on either side completes the first layer The uppermost and lowermost sutures are passed before the remainder so as to ensure closure of these two danger points. With

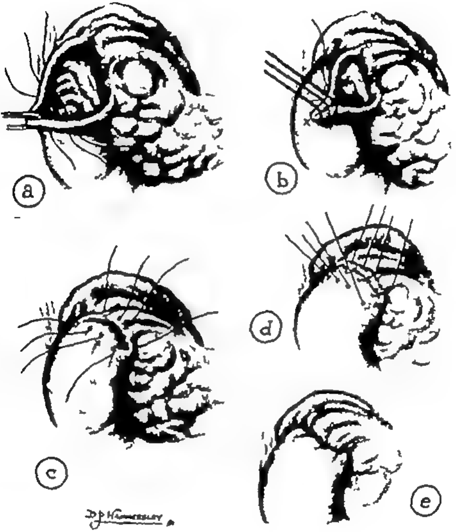

Fig 368.—The inturning method of closure of the duodenum in the presence of a chronic penetrating ulcer in the posterior wall. (*F H Bentley British Journal of Surgery* .)

the exception of the central stitch, all sutures of this row are passed before they are tied. A second layer of interrupted thread sutures is passed to bury the first layer each stitch taking a secure bite of the thickened edge of the pancreas behind, and of the anterior duodenal wall in front (*Fig* 368, d, e). The suture line is reinforced by local omental flaps.

ALTERNATIVE TO SUBTOTAL GASTRECTOMY

1. A Gastric Ulcer penetrating the Pancreas or the Liver is found.—After opening the lesser sac, the stomach is separated from the organ to which it is attached by sharp and gauze dissection The indurated margin of the resulting hole in the *stomach* is pared away with scissors the defect is then closed with a series of interrupted stitches of strong

chromic catgut passed through all layers of the stomach. With a view to preventing re-adherence and leakage, the suture line is reinforced with a free omental graft. When the base of the ulcer is formed by the pancreas it is dangerous to cauterize the ulcer bed leakage of pancreatic ferments will occur when the slough separates. If there is an open vessel in the floor of the ulcer sutures are passed beneath the ulcerated area and tied lightly over oxycel or gelfoam sutures tied tightly are liable to cut out. If there is no obvious vessel in the floor of the ulcer it can be left alone There is no objection to applying a diathermy or cautery to a cavity left in the liver Whether in the pancreas or the liver drainage of the ulcer cavity should be provided.

2. A Non-penetrating Chronic Gastric Ulcer is present.—

a. If as is often the case, the ulcer lies on the posterior wall transgastric suture can be carried out (*Fig* 369) All the sutures must be deeply placed before tying Should time and circumstances permit, a diathermy point can be thrust through the base of the ulcer and the ulcer destroyed by electrocoagulation. The edges of the stomach surrounding the ulcer are then *united firmly by sutures passing through the whole thickness* of the stomach wall they hold well The incision in the anterior wall of the stomach is closed.

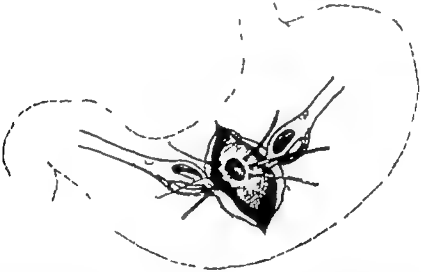

Fig 369 —Transgastric suture of a bleeding gastric ulcer

b In the comparatively rare event of the ulcer being situated on the anterior wall of the stomach, the cautery is thrust through the centre of the ulcer and, by a rotatory movement, the greater part of the ulcer is destroyed. The resulting perforation is sutured.

c. The relatively common lesser curve ulcer is a somewhat more difficult problem. As a rule, if the lesser omentum in the neighbourhood is divided between ligatures the base of the ulcer (sometimes saddle-shaped) becomes more accessible. Two stout *ligatures* are then passed deeply through the musculature of the lesser curve on either side of the ulcer Incidentally these ligatures secure the right and left gastric vessels but their chief object is to act as tractors, while the cautery is plunged in a downward direction through the centre of the ulcer After as much as possible of the ulcer has been destroyed, the perforation is firmly sutured.

Fig 370.—Petechial hæmorrhages around the peritoneal aspect of a chronic peptic ulcer These become very noticeable after gently rubbing the surface with gauze.

3. There is an Ulcer on the Anterior Wall of the Duodenum.—Even if there is a scar on the anterior surface of the duodenum, and, when rubbed with gauze that scar exhibits surrounding petechial hæmorrhages (*Fig* 370), thereby displaying activity a second ulcer on the posterior wall of the duodenum *should be excluded*. This can be accomplished by burning a hole in the anterior wall of the duodenum through the centre of the scar large enough to admit the little finger If no ulcer can be felt on the posterior wall, the perforation is closed and as far as the arrest of

hæmorrhage is concerned, the result is likely to be highly satisfactory If an ulcer is present on the posterior wall the opening in the anterior duodenal wall can be enlarged with scissors sufficiently to enable the ulcer to be undersewn with interrupted stitches. Closure of the rather large incision in two layers is likely to result in narrowing of the lumen of the duodenum as a consequence posterior gastrojejunostomy becomes necessary

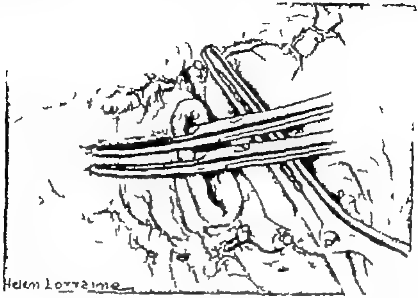

Fig 371 —The stomach has been bisected one to two inches from the pylorus, and the anterior wall of the distal segment is about to be opened.

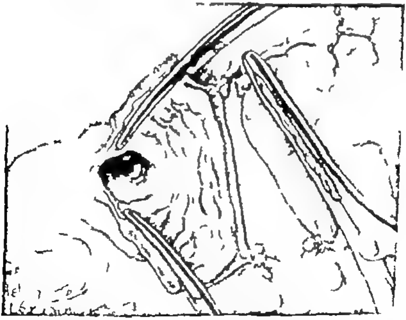

Fig 372.—This manœuvre exposes deeply placed ulcer on the posterior wall of the duodenum. (*After Allen and Benedict*)

Therefore even if it is necessary to destroy an ulcer of the anterior wall, it is better to display the ulcer on the posterior wall in the manner next to be described.

4. When an Ulcer Crater can be palpated in the Posterior Wall of the Duodenum.—The best way of exposing the ulcer is as follows after dividing the omenta in the immediate neighbourhood between ligatures, the pyloric antrum is bisected between clamps about 1½ in. (3·8 cm.) proximal to the pylorus. The distal clamp is removed and two long hæmostats grasp the anterior wall of the distal segment (*Fig* 371), which is divided between

them. The anterior wall of the duodenum is divided sufficiently to expose the ulcer fully (*Fig.* 372). The ulcer is then undersewn with interrupted sutures which in the case of deep craters, are tied over a piece of oxycel or gelfoam. The divided anterior wall is sutured in two layers, and the cut distal end of the stomach is likewise closed and infolded. Finally the cut proximal end of the stomach is anastomosed to the side of the first coil of jejunum.

The pyloric antrum should be resected with or without the ulcer (depending on its site) in about two months time. This operation is comparatively simple, for the œdema will have abated completely. The removal of this segment greatly minimizes the development of a jejunal ulcer.

LAPAROTOMY WHEN THE CAUSE OF THE HÆMORRHAGE IS DOUBTFUL

After palpating the stomach and the duodenum, if an ulcer is not readily apparent, proceed as follows:—

1. Inspect the liver for evidence of cirrhosis.

2. Examine an upper coil of jejunum. The colour of the intestinal contents is visible through the jejunal wall. If it is dark (due to contained blood) trace the coil to the duodenojejunal flexure. If darkness is evident as far as the third portion of the duodenum, obviously the blood must have come from somewhere above this point. Therefore re-examine the stomach and duodenum. Should no lesion be found, acute gastric ulceration must be assumed.

3. If the coil of jejunum referred to above is not dark, examine the lower ileum. Blood within the ileum is particularly obvious through the semitransparent wall of this part of the intestine. Look for a Meckel's diverticulum. In its absence palpate the ileum for an intestinal polyp.

4. If there is no blood in the jejunum or ileum, and the hæmorrhage has occurred per rectum, it must have come from the large intestine. Therefore examine the large intestine, and particularly the pelvic colon, for an inflamed diverticulum.

MELÆNA AFTER APPENDICECTOMY

Very occasionally not more than once in 800–1000 cases, melæna complicates appendicectomy. It is well to know of this possibility for (rightly) the first thought is that the patient has a bleeding duodenal ulcer. The cause of hæmorrhage has invoked more discussion than its rarity and dangers warrant. Power's explanation that a tiny abscess under the purse-string suture bursts through the appendicular stump and causes secondary hæmorrhage is satisfying. I have seen but one undoubted example of this condition, and a transfusion of 2 pints (1 L) of blood remedied matters permanently.

Massive Hæmorrhage from Œsophageal Varices.—*See* Chapter LXV

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CHAPTER XXIX

THE STOMACH *(continued)*

ACUTE DILATATION OF THE STOMACH

Owing to the frequent use of post-operative gastric aspiration, acute dilatation of the stomach occurs less frequently than formerly. It can occur after any operation, or after the application (under an anæsthetic) of a plaster-of-Paris jacket, but the greatest incidence follows operations on the biliary passages and pelvic organs. More rarely the condition complicates the state of shock, such as might be occasioned by a fractured femur.

It is of paramount importance to recognize this condition promptly, *for practically all unrecognized cases end fatally*. The day should have passed when the condition remains unsuspected until enormous effortless vomits, soon becoming the colour and consistency of the storm water of a peat laden stream, make the diagnosis undeniable. Acute dilatation of the stomach can be diagnosed before the patient vomits.

Diagnosis.—We are summoned to the bedside because there is something amiss. The pulse is rising but the patient does not necessarily look gravely ill. He is not in any pain, but usually feels uncomfortable. Vomiting occurs relatively late. Let alone vomiting, at this stage he does not perhaps experience even nausea, but an occasional hiccup is not uncommon. The output of urine is invariably scanty, although during the first few hours this cannot be gauged with accuracy. A slight fullness may be seen in the hypochondria, obliterating the normal sulcus, immediately beneath the costal margin (*Fig.* 373), but in an obese subject this is difficult to assess. Even if the diagnosis of acute dilatation is merely on the horizon, no possible harm can accrue from passing a gastric aspiration tube. If large quantities of dark fluid are withdrawn, other things being equal, the diagnosis is confirmed.

Fig. 373.—Obliteration of the normal slight concavity beneath the costal margin is a somewhat characteristic sign in acute dilatation of the stomach.

Treatment.—

1. Empty the stomach and keep it empty (*Fig.* 374). The fluid aspirated must be measured and charted.

2. Administer dextrose-saline intravenously. Remember, however, that in this condition the gastric aspirate contains a large quantity of chlorides. Therefore the second bottle should be normal saline without dextrose. Thereafter sufficient saline solution is given to prevent hypochloræmia. In cases where the condition persists for 36 hours, one bottle of Darrow's solution (to supply K ions) should be substituted for a bottle of dextrose-saline during the 24 hours.

3. Gastric lavage is unnecessary. Unless it is performed with normal saline solution, it has the danger of making the patient alkalæmic. It is best avoided altogether.

4. The patient is allowed to drink a few drachms of water each hour. It is aspirated promptly. Soon after the translucency of the gastric juice has been restored, Starr recommends that fluid and electrolytic balance be maintained by gravitating the necessary dextrose and electrolytic solutions through the gastric aspiration tube by the drip method, provided always that gastric motility has been proved to be adequate. In this way the danger of œdema of the lungs is avoided.

5. Frequent chemical examinations of the blood should be made, and as soon as the blood-chlorides return to normal, saline solution *per se* should be discontinued.

6. In cases where the blood pressure remains low, intravenous infusion of dextran or, better, blood transfusion is required.

7. A high concentration of oxygen, given with a polymask or other type of mask for a long period, is decidedly beneficial.

8. The parenteral administration of vitamins B and C is of value, and should be given in every case.

If the case is one of early acute dilatation without other complications, signs of improvement are not long delayed (*Fig* 374) The pulse improves, and the fluid aspirated lessens in quantity and becomes clearer Even when the fluid aspirated is quite clear danger is not passed, for gastric dilatation is prone to recur The gastric aspiration tube should be left in place for at least thirty-six hours after the stomach has apparently regained its tone Before withdrawing the tube a gastric motility test (p 107) is essential.

Fig 374 —Severe acut d latation of the stomach occurred four hours before this photograph was taken. The day previously the patient had had cystectomy performed for carcinoma of the bladde

GASTRIC TETANY (ALKALÆMIA)

This rare complication, seen in cases with *chronic dilatation of the stomach*, may occur *after gastric operations. The spasms are usually confined to the extremities*, and the attacks are accompanied by dyspnœa and cyanosis. If the stomach is dilated, it must be emptied and kept empty by aspiration. Continuous intravenous saline and glucose should be administered without delay Three cases of gastric tetany responded immediately to calcium gluconate, 10 ml. of a 10 per cent solution, injected intravenously (I I Price) In order to adjust the chloride balance, normal saline solution should be administered as soon as possible

ACUTE VOLVULUS OF THE STOMACH

Volvulus of the stomach takes place in two main directions—around a vertical axis and around a horizontal axis (*Fig* 375). In the latter variety which is more usual, the pyloric antrum may come to lie in front of the cardia (*Fig* 376). Normally the omenta, with their contained blood vessels, allow the stomach to rotate through 90 around its longitudinal axis only For abnormal rotation to occur there must be considerable stretching of the gastric ligaments, and particularly of the gastrohepatic omentum. Diaphragmatic hernia, gastroptosis, and hour-glass stomach predispose to volvulus of the stomach, which is a very rare emergency In spite of this, acute volvulus of the stomach should not remain undiagnosed for many hours, as is so often the case. The condition is extremely urgent.

Diagnosis.—Acute volvulus of the stomach is equally common in both sexes, and may occur at any age although it is encountered most frequently in elderly persons. The condition usually gives rise to recurrent attacks of upper abdominal pain with distension, accompanied by retching One day the volvulus fails to rectify itself. The symptoms

are sudden pain, often excruciating commencing after a full meal and increasing from hour to hour considerable shock retching with small amounts of frothy vomitus *without bile* Melæna occurs frequently Often there is a large resonant swelling in the upper abdomen. The fact that a gastric aspiration tube often cannot be passed aids *in the diagnosis. Radiography* shows a large gastric air-shadow Early operation is imperative otherwise the distended stomach, with an impoverished blood-supply will burst.

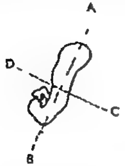

Fig 375.—The main axes of rotation of the stomach. (*E. A Spriggs and O. A Marxer*)

Fig 376 —Horizontal volvulus of the stomach.

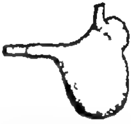

Fig 377 —Stomach after reduction. (*James Buchanan British Journal of Surgery* .)

Laparotomy —Even with the abdomen open volvulus of the stomach may be difficult to recognize Buchanan found blood-stained fluid in the peritoneal cavity and a swelling that had the transverse colon above it The swelling was covered with a thin layer of omentum. This was incised and a bluish mass presented. Further examination revealed large tortuous *veins proceeding from the greater curvature* After a stomach tube had been passed by the anæsthetist a large quantity of gas escaped, followed by blood-stained material. It was then found that the deflated stomach could be untwisted (*Fig* 377).

Fig 378.—A simple form of gastropexy using unabsorbable sutures.

Often it is impossible to pass a stomach tube in which case the wall of the stomach must be punctured in a manner similar to that shown in *Fig* 392, p. 344 Afterwards the puncture is closed by the insertion of a purse-string suture *Detorsion* can then be accomplished. When the condition of the patient permits, a simple form of gastropexy (*Fig* 378) should be performed. Owing to delay in operation, the mortality rate is 60 *per cent.*

EMERGENCIES ARISING AFTER GASTRIC OPERATIONS

Probably no class of case is so worrying as dealing with an emergency following a gastric operation. Particularly unenviable is the lot of a young surgeon who has to decide the right course of treatment when he has not performed the original operation.

Two special emergencies after partial gastrectomy and gastro-enterostomy are (1) *Hæmatemesis* (2) Vicious circle vomiting Fortunately both of these are now rare for this very reason we must be adequately prepared for them.

Hæmatemesis and/or Melæna.—Loosening the clamps after a second row of sutures has been inserted and waiting a few moments to see if there is any bleeding point has reduced the incidence of post-operative hæmatemesis enormously Though bleeding following operations upon the stomach is nearly always from a vessel in the suture line the possibility of the ulcer (if it has not been removed) being the source of the hæmorrhage must be considered. In order to get a thorough grasp of the type of case with which we are at present concerned we will describe an actual example.

The patient had subtotal gastrectomy performed early in the afternoon. At 10 p.m. he vomits *rather bright looking blood. Twenty* minutes later he has a large vomit consisting of clots and bright red blood. How is the case to be managed?

If the general condition is good, adopt the following :—

1 Pass a gastric aspiration tube and wash out the stomach gently with normal saline *solution at* 120 F (48.8 C), *and then proceed as described on p.* 286. *A sufficient time*

having elapsed for the styptics to act, it is wise to continue with the continuous gastric aspiration, for bile is a powerful anticoagulant.

2. Have the pulse recorded every half hour on a separate piece of paper pinned to the chart.

3. Give morphine, ¼ gr (16 mg) subcutaneously. Further injections of ⅙ gr (10 mg) can be given in due course if required.

4. Commence blood transfusion as soon as possible.

5. Give vitamin K* intramuscularly twice or three times a day for two or three days.

6. Raise the foot of the bed on blocks.

While a most conservative attitude should always be adopted towards reopening the abdomen, there should be no such attitude towards blood transfusion. I have seen resuture of a bleeding anastomotic suture line brought to a successful conclusion when death would have been inevitable without operation. Nevertheless, such cases are, unfortunately exceptional. A more usual result is to find that, whilst the patient recovers from the second operation and gives every hope of recovery, a curious post-operative peritonitis supervenes about the fifth day and death quickly follows, the terminal stages being characterized by a low muttering delirium. A former colleague of mine noted this unhappy sequence of events in three consecutive cases. This depressing picture should not induce us to fold our hands when we ought to be opening our instrument bags. If the bleeding continues in spite of transfusion, if it is thought wiser to hurry forward the operation, or if suitable blood cannot be obtained quickly enough, then operation must be undertaken.

Operation.—The skin is prepared as carefully as possible. The sutures are cut with scissors, and the incision is reopened. It is unwise to omit to place towels accurately on the skin edges, for infection is very prone to supervene when the abdomen has to be reopened before the original incision has had time to heal. In the case of a subtotal gastrectomy two deeply placed stay sutures are inserted near the extremities of the anterior wall of the gastric stump, in order to be enabled to draw it downwards and forwards. After the area has been isolated with abdominal packs, an incision is made into the stomach parallel to the line of anastomosis. In the case of a gastrojejunostomy the incision can be vertical (*Fig.* 379). After sucking and swabbing out the blood and blood-clot look first at the posterior suture line and then at the anterior. When no bleeding point is discovered, the posterior suture line is made more accessible by placing a stay suture at each end. Using a lockstitch the whole circumference of the stoma is oversewn. This must control any hæmorrhage from the suture line. The incision in the anterior wall of the stomach is closed by a double layer of sutures.

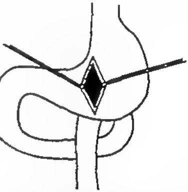

Fig. 379.—Method of inspecting the interior of the stomach by incising the anterior wall. By this method a bleeding point on the line of the anastomosis can be seen.

Remember that post-operative peritonitis and bronchopneumonia are prone to follow this reopening of the abdomen. Every possible precaution of packing off the area with damp abdominal packs should be taken. Antibiotic therapy should be commenced forthwith and parenteral fluid administered with especial care to avoid overhydration.

Remote Severe Post-operative Melæna.—Severe melæna sometimes occurs a week to ten days or more after gastrojejunostomy. The particular type of case this uncommon complication seems to favour is duodenal ulcer with stenosis. When hæmorrhage occurs so remotely it is unlikely that the bleeding is coming from the anastomosis—it is the ulcer that is bleeding. This type of hæmorrhage is liable to be overlooked until the patient is severely anæmic, especially as the patient has probably been doing well up to the time of the onset. The management of the case is in all respects similar to that of melæna from other causes (see Chapter XXVIII).

Failure of the Stoma to function: Vicious Cycle.—During the first 48 hours after operations upon the stomach, in a large proportion of cases bile-stained fluid is aspirated. In most cases this lessens in amount 24–48 hours after the operation. The amount of

* Vitamin K.—Synkavit (Roche); Kapilon (Glaxo).

fluid aspirated must be recorded accurately If after 48 hours, large quantities of bile are recovered by aspiration or if vomiting commences, a serious view of the case must be taken. Obviously the stoma is not functioning—it is very suspicious of vicious cycle. True, it is possible that the obstruction may be due to œdema of the stoma, a rather theoretical concept. If the condition of the patient is not deteriorating, it is often advisable to rely upon gastric aspiration and continuous intravenous infusion until the fourth or fifth post-operative days, a course that should be pursued for even longer when the calculations show that even one-third of the bile is passing through the stoma. In order to make these calculations accurate charting of the fluid recovered by aspiration is essential.

While we are most reluctant to reopen the abdomen, a time is reached when in our judgment, it is unwise to delay longer

Special precautions to prevent infection when reopening the abdomen are the same as those described on p 207 The first thing to ascertain is whether there exists an obvious obstruction distal to the anastomosis. By tracing the loop downwards for about a foot, especially if it is not dilated this possibility is ruled out at once.

Fig 380.—Anastomosing the efferent and afferent loops. The second layer of sutures is about to be inserted.

If the operation has been a partial gastrectomy (Polya type) *anastomose the afferent to the efferent loop. These* loops are accessible and the technique is not difficult (*Fig* 380).

If the operation was a posterior gastrojejunostomy turn up the colon and observe the transverse mesocolon and *the stoma. Perhaps the hole in the transverse meso*colon is small, and the anchoring sutures have failed to prevent the anastomosis slipping upwards into the lesser sac, thereby kinking the jejunum. *Such findings are quite exceptional.* If there is a definite kinking of the efferent *loop from this cause, the stoma is drawn downwards* and the stomach wall in the region of the anastomosis is firmly sutured to the mesocolon, care being taken to avoid including the middle colic artery in one of the stitches. In the majority of cases the only safe course is to perform an anastomosis between the *afferent* and *efferent limbs.* Because no loop gastrojejunostomy is always performed, the efferent loop must be brought to the afferent limb of the anastomosis and the operation, which is difficult, is best carried out with interrupted stitches.

If the operation was an anterior gastrojejunostomy anastomose together the efferent and afferent loops. These loops are accessible and the operation is simple.

If the previous operation has been a gastroduodenostomy the indication is clear—perform gastro-jejunostomy

Vomiting commencing after a Spell of Satisfactory Progress.—There are three possibilities to be considered —

1 If the vomits are large, the patient collapsed, and particularly if these untoward symptoms come on suddenly it must be assumed that some degree of *acute dilatation of the stomach* is present, and treatment is conducted accordingly (see p. 201).

2. If the stoma progressively *fails to function cicatricial contraction of the mouth of the efferent limb* is probable, and the treatment is the same as that of vicious cycle

In the case of a Billroth I operation, if cicatricial c n occurs the material vomited is stomach contents only When feeds are and gastric aspiration is instituted, little or nothing is withdrawn. In re-operation is the only course, and the best pr is to unpick th close the duodenal end, and make a new anast the pro the stomach and the side of a loop of the commen jejunum bro of the colon. A

3. The possibility of high tion about graph may be of diagnostic and

SMALL-BOWEL OBSTRUCTION FOLLOWING PARTIAL GASTRECTOMY

The condition is probably more frequent than published cases would indicate. Stammers collected 16 cases, in 15 of which the anastomosis was antecolic. The small intestine passes through the gap between the anastomosis and the transverse mesocolon. Herniation occurs either from right to left (*Fig* 381) or from left to right. The amount of intestine so herniated may be as little as 9 in. (24 cm.) or as great as 19 ft. (5·7 m.) The condition is one of high intestinal obstruction which usually commences between the third and the eighteenth post-operative days, but the symptoms are atypical because so often gastric aspiration is in progress, or is re-instituted soon after the first or second vomit. In the presence of continuous intravenous fluid therapy and gastric suction, the pain is not always colicky indeed in most of the reported cases pain was continuous and of increasing severity If the dual test (see p. 465) were applied after 24 hours gastric suction, remitting pain of increasing severity would occur as in other cases of intestinal obstruction.

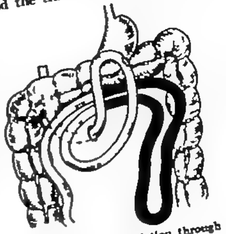

Fig 381.—Herniation through the gap between an antecolic anastomosis and the transverse mesocolon. (*After F. A. R. Stammers.*)

Treatment.—When the condition is strongly suspected, the abdomen must be re-opened if necessary under local anesthesia. The hernia is usually reducible without particular difficulty Gangrene due to long delay is present in 30 per cent of cases. The mortality is also 30 per cent but the fatalities are not limited entirely to cases of gangrene

The only method of preventing herniation through the hiatus created during the operation of partial gastrectomy is to obliterate it at the time of the operation.

In only one of Stammers series was the anastomosis retrocolic.

Strangulation of small intestine around a gastrojejunostomy stoma is very uncommon and has occurred most often about a fortnight or three weeks after the operation. The small intestine passes behind the afferent loop, and becomes strangulated (*Fig* 382) Like similar obstruction occurring after partial gastrectomy the hernia is usually easily reducible Because the transverse mesocolon is anchored to the stomach at the conclusion of a gastrojejunostomy herniation of the small intestine into the lesser sac now hardly ever occurs in days gone by before this step was carried out meticulously the complication was not infrequent.

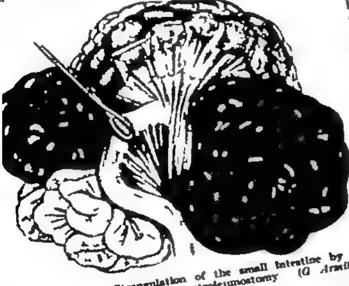

Fig 382.—Strangulation of the small intestine by the afferent loop of a posterior gastrojejunostomy (*G Armitage British Journal of Surgery*)

LEAKAGE AND PERITONITIS AFTER GASTRECTOMY

Prevention of a Duodenal Fistula.—If towards the end of any operation of gastrectomy of the Polya type a gastric aspiration tube is passed through the stoma into the proximal jejunum towards the blind end of the duodenum, and continuous suction is applied for four days, the intraduodenal pressure is kept low during the early stages of healing of the closed end of the duodenum.

A duodenal fistula develops in 3 per cent of cases of partial, subtotal, and total gastrectomy Usually it occurs comparatively late, i.e., on the tenth to the twelfth day For this reason, until this danger is passed, some form of drainage of the area should be provided. The drainage tube (or the piece of corrugated rubber) should be moved and shortened, but in cases where difficulty was experienced in closing the duodenum or the stomach, and particularly in cases where the ulcer penetrated the pancreas, a potential vent through the abdominal wall should be provided for at least 10 days. This advice is the outcome of a long association with gastric surgery If leakage occurs and no drainage is provided, a common sequence of events is the development of a subdiaphragmatic or subhepatic abscess which, after surgical drainage, results in a fistula that digests the abdominal wall. In other cases diffuse peritonitis results. Occasionally the provision of drainage fails to prevent the development of widespread peritonitis. Of 18 cases of duodenal leakage where no drainage was provided, 11 died (Larsen and Foreman)

Fig 383.—Common sites of fistulæ following partial gastrectomy

A fistula can occur from the blind end of the duodenum (A) or what is not very uncommon, from a leak at (B). (*Fig* 383) The latter is, of course strictly a jejunal

Fig 384.—On the tenth day after operation a serious fistula followed partial gastrectomy for a huge ulcer penetrating the pancreas. The measures detailed in the text were carried out. Bile-laden fluid from the fistula was collected in the bottle and periodically the contents of the bottle were gravit ted into the jejunum. Excoriation of the abdominal wall was insignificant.

fistula, but there is no means of distinguishing (A) and (B) from an inspection of the discharge. A fistula at (B) should be suspected when there was no difficulty in closing the duodenum, but when the ulcer was high in the stomach and the blood-supply to the lesser curve may have been jeopardized. From the practical standpoint the treatment is the same Perform jejunostomy under local anæsthesia by the technique described on page 523, at the very earliest opportunity The patient is then nursed in Fowler's position and after taking full precautions to protect the skin about the fistula from becoming excoriated (see Chapter XLVII) and abdominal wall from disrupting (see p. 172) suction drainage is instituted (*Fig* 384). By exercising a little ingenuity in the manner of applying the suction in each individual case the fistula can be kept under control. Jejunal feeding (*Fig* 385) is carried out in accordance with the instructions given on page 524

Aetiology and Prophylaxis.—Much investigation has been carried out as to why a duodenal fistula sometimes follows closure of the duodenum in subtotal and other forms of gastrectomy The presence of a drainage tube impinging upon the closed duodenum has been incriminated, but if the drainage tube is soft or if the drain is of corrugated rubber

it is impossible for it to cause pressure necrosis. Moreover there is no need for the drain to touch the duodenum.

There is little doubt that leakage from the duodenal stump is due to one or more of three causes —

1 Mobilization of even $\frac{3}{4}$ in. (2 cm.) of the duodenum is liable to imperil the blood-supply of the stump and so lead to necrosis and leakage.

2. Anæmia, hypoprotinæmia, avitaminosis, and dehydration all predispose to failure of intestinal lines of suture to heal.

3. Probably the most important factor is that there is obstruction to the exit of the blind afferent loop and the increased pressure therein leads to a 'blow-out' (R. W McNealy et al.)

Fig 385 —This photograph was taken fifteen days after jejunostomy had been performed. By this time the fistula had almost closed, but to be on the safe side the patient is still receiving all his nourishment through the jejunostomy tube The fistula healed within eighteen days.

RETROGRADE JEJUNOGASTRIC INTUSSUSCEPTION

Retrograde jejunogastric intussusception can occur after gastrojejunostomy or partial gastrectomy —

1 The afferent limb may intussuscept into the stomach.

2. The efferent limb may undergo retrograde intussusception which either stops short of the stoma, or passes through it into the stomach (*Fig* 386)

3 Both afferent and efferent limbs together may intussuscept into the stomach.

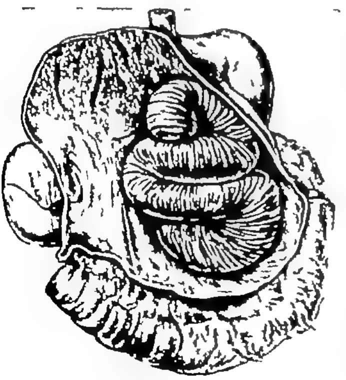

Fig. 386 —Retrograde intussusception of the small intestine after gastrojejunostomy

All are very uncommon. Women are affected more often than men, and in two cases the patient was pregnant at the time. The intussusception has occurred between a few days to several years after the operation.

If the condition is borne in mind it is not impossible to make a correct pre-operative diagnosis. Symptoms occur suddenly The pain is griping epigastric, colicky Vomiting soon occurs, and is frequently repeated. The vomitus at first is food then bile, and then blood. If rigidity and tenderness are absent perforated gastrojejunal ulcer can be ruled out. Usually a lump can be felt in the epigastrium.

One of the most helpful diagnostic aids is a plain radiograph of the abdomen. This sometimes shows the typical step-ladder pattern of jejunal loops within the gastric outline (A. White).

Hamilton Drummond's Case —

A platelayer aged 35 on the previous day was seized with spasmodic epigastric pain after taking food. The pain, coming in spasms, had continued, and he had vomited many times, latterly almost pure blood. The patient looked ill. The pulse was 96 and the temperature 98 F (36·6 C.). Whilst under observation he had several attacks of pain accompanied by small vomits of blood. Examination revealed a scar in the epigastrium. He had undergone gastro-jejunostomy sixteen years previously. There was no tenderness or rigidity. Two hours after admission laparotomy was performed. The proximal loop of the anastomosis was enormously dilated. About 6 ft. (1·8 m.) of small intestine from the distal loop had become intussuscepted into the stomach. This was reduced easily.

After the abdomen has been opened and the condition recognized, reduction is undertaken by squeezing the mass in the stomach towards the stoma.

When operation is undertaken at a late stage reduction may be impossible. In such circumstances, an incision in the anterior wall of the stomach should be extended until the edge of the stoma is reached. Once the ring that imprisons the intussusception has been divided, reduction is possible. Should the gut be gangrenous resection must be undertaken. When time permits, stitching together the afferent and efferent limbs will help to prevent recurrence.

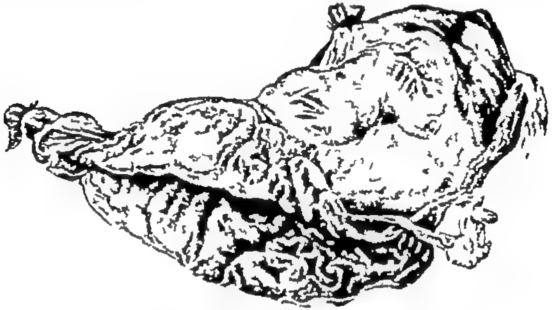

Fig. 387.—Lord Moynihan's case of phlegmonous gastritis.

ACUTE PHLEGMONOUS GASTRITIS

This condition was called by E. Rixford "acute suppurative cellulitis of the stomach," a name that conveys an accurate picture of its pathology. The stomach is swollen and angry and pus is found in the submucosal layer (*Fig.* 387).

Lord Moynihan's Case —

The patient, a boy aged 17 was taken ill a few hours after eating pork pie. He complained of acute abdominal pain, and there was exquisite epigastric tenderness. The epigastrium was distended.

The boy was very ill; the pulse was never less than 118; there were collapse, vomiting and profound prostration, which ended in death about thirty-eight hours after the onset of symptoms. At the post-mortem a typical and most acute phlegmonous gastritis was found. No lesion of the mucous membrane of the stomach could be seen.

When the stomach has been examined after death, the mucosa has been found to be intact and comparatively normal in all but a few instances. In these exceptions a carcinoma or a chronic gastric ulcer has been present.

The offending organism is nearly always a streptococcus. Exceptionally a pneumococcus is the cause.

Jennings Marshall's Case.—

A man of 54 during convalescence from pneumonia complicated by empyema, commenced to vomit. He continued to vomit copious bright red jelly. There was rigidity in the upper abdomen, but little tenderness or other symptoms. Laparotomy revealed an œdematous stomach with the gastric wall ⅓ in. (8.5 mm.) thick. The abdomen was closed and the patient recovered.

In its most acute form acute phlegmonous gastritis invades both walls of the stomach from the cardia to the pylorus. There is a localized type that, when situated near the pylorus, has been treated successfully by partial gastrectomy, as in Gerster's cases. There is also a variety mainly confined to the duodenum.

The absence of characteristic signs and the rarity of the condition make pre-operative diagnosis impossible. Probably some cases resolve and the true condition never comes to light. In the very acute generalized forms, acute pancreatitis, perforated gastric ulcer, and pneumonia enter the clinical picture, while in the variety confined to the pylorus, acute cholecystitis appears to be the most likely pre-operative diagnosis.

Recognition at Laparotomy.—On opening the abdomen (usually on a diagnosis of perforated peptic ulcer) some perigastric peritonitis is likely to be found. The stomach is infiltrated and inflamed, its walls being likened to wet blotting paper. If doubt exists as to the nature of the condition, insert a hypodermic syringe into the stomach wall. Thick muddy pus is withdrawn into the syringe from the submucosa. If pus is aspirated a small incision should be made down to the submucous layer. In either event drainage leading to the anterior surface of the stomach *and also to the lesser sac* must be provided. If the stomach wall has been incised the greater omentum should be stitched to the lower part of the incision so as to form an omental barrier. If pus has been aspirated it should be sent for culture and antibiotic sensitivity.

Drainage should be maintained until the pulse-rate and temperature reach normal.

Antibiotic therapy is of course the mainstay of treatment.

GASTROSTOMY

There are occasions when gastrostomy to relieve starvation from œsophageal obstruction is a semi-emergency (*Fig.* 388). The operation can easily be carried out under local infiltration. A short incision is made a little to the left of the midline. The rectus muscle is split

Fig. 388.—Patient about to undergo gastrostomy. He has only been able to keep down little water during the past week. Carcinoma of the œsophagus.

the peritoneum opened, and the stomach, which is often small and retracted, is found and drawn to the surface. A portion of the anterior wall about the middle of the body of the stomach is selected and held up by two Lane's forceps. With a narrow-bladed scalpel, a stab is made into the lumen of the stomach; this is followed by a hæmostat, the jaws of which are opened to make quite sure that the stab has passed through all coats of the stomach. The scalpel and the hæmostat being infected, are discarded. A suitable

rubber catheter (not too small) is selected and an extra eye is cut near the tip. About 3 in. (7·5 cm.) of the catheter are passed into the stomach, and the catheter is transfixed by a catgut stitch that anchors it to the stomach wall. A second catgut stitch may be necessary to make a snug junction. Three rows of unabsorbable purse-string sutures are employed to invaginate the stomach wall, producing the well-known unspillable ink-bottle effect (*Fig.* 389). The stomach in the immediate vicinity of the exit of the catheter is firmly sutured to the peritoneum and the wound is closed. At the conclusion of the operation it is customary to give a feed while the patient is still on the operating table, in order to be certain that the tube does, in fact, lie within the lumen of the stomach. As soon as the patient has been returned to bed drip feeding can commence.

Fig. 389.—The Abbé-Kader Senn-Stamm operation of gastrostomy.

HYPERTROPHIC STENOSIS OF THE PYLORUS

Hypertrophic pyloric stenosis of infants is seldom an emergency condition. Occasions arise when it becomes really urgent to relieve the pyloric obstruction. Dehydration is corrected by the administration of *dextrose-saline* solution given either intravenously or subcutaneously with hyaluronidase. The stomach is kept empty during this period by gastric aspiration. If it has not been tried already Eumydrin (atropine methylnitrate) 1–10,000 *freshly* made can be given by mouth, commencing with 0·5–1 ml. half an hour before each feed, and if the pylorus relaxes, increasing to 2·5–3 ml. Small hourly feeds of milk—if possible mother's milk—diluted with 5 per cent dextrose are tried, but if the greater part does not pass through the pylorus, it is unwise to persevere for more than six hours.

Rammstedt's Operation.—The operation can be conducted under local anæsthesia (*Fig.* 390). The abdomen is opened by an incision over the pylorus, the rectus muscle being either retracted outwards or split vertically. The greatly hypertrophied pylorus is held in the finger and thumb and rotated somewhat so that the upper surface comes to look forward. The muscle coats are incised down to the mucosa (*Fig.* 391), great care being exercised not to perforate the mucous membrane, an accident especially

Fig. 390.—Infiltrating the abdominal wall with local anæsthetic.

Fig. 391.—Hypertrophic stenosis of infants—incising the pylorus.

liable to occur where the hypertrophied pylorus terminates abruptly to join the comparatively thin duodenum. Using a blunt dissector the thickened muscle, which cuts like an unripe pear, is eased from the mucosa at the bottom of the wound and the mucosa bulges into the incision. It is a good practice to place a tiny piece of muscle from the rectus in the pyloric incision—this helps to arrest oozing. If the mucosa is opened accidentally (this will become evident if air is squeezed gently from the stomach into the duodenum) it should be closed with a catgut stitch, and a corrugated rubber drain inserted through the incision. The abdomen is closed. The feeding of the patient after the operation requires strict supervision. Very small feeds are the order of the day, especially during the first three days.

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CHAPTER XXX

THE GALL-BLADDER AND BILE-DUCTS

GALL-STONE COLIC

MORPHINE and its derivatives, so long the standard treatment of gall-stone colic, do not relieve the pain as often as would be expected. If enough of the narcotic is given to render the patient stuporous, it is liable to increase the damage of a liver already damaged. What should be given is a drug which relaxes spasm of involuntary muscle (morphine causes such musculature to contract). A drug fulfilling these requirements is pethidine[1] (B.P.C.), 2 ml. (100 mg.) intravenously. In severe cases the dose can be repeated in one hour.

As soon as the acute pain has passed off is the time to apply heat in some form to the right upper abdomen. It is often impracticable to expect the patient to tolerate hot applications while rolling in agony.

When an attack of biliary colic is followed by jaundice, it is almost certain that a stone has entered the common bile-duct. Even when the jaundice is unmistakable, good results often follow expectant treatment. It should be an unwavering rule never to be in a hurry to operate upon a patient who has recently had an attack of gall-stone colic. Even in cases of moderately deep jaundice, by waiting patiently for a week or more frequently we can spare the patient undergoing an operation at an unfavourable time for so often the jaundice clears, even though at the subsequent operation a stone or stones are found in the common bile-duct. Jaundice means depressed liver function. To operate upon patients with a depressed function will result in a percentage of unexpected deaths in the post-operative period, fatalities which are often unexplained by morbid anatomy (the hepatorenal syndrome).

Three or four days after the symptoms have passed off and the jaundice if present, has cleared, cholecystography should be carried out. In most cases the examination will prove that the gall-bladder is diseased. If so (and possibly in the absence of radiological confirmation) an elective operation should be undertaken within the next few days.

While the above instructions apply in cases of gall-stone colic with or without mild obstructive jaundice, from time to time cases will be encountered where the jaundice becomes deeper and the patient's temperature suggests that cholangitis is likely to supervene. In such circumstances, to delay unduly is a surgical misdemeanour. The operative treatment of obstructive jaundice is discussed on p. 823.

CHOLECYSTOSTOMY

At the present time it is fashionable to regard cholecystostomy with considerable condescension, but with the proviso that it is desirable only in cases of the direst urgency or when the surgeon is too timorous or inexperienced to perform cholecystectomy. This patronizing attitude is unwarranted: cholecystostomy is an excellent atraumatic procedure which can be carried out readily under local anaesthesia. The surgeon should never feel ashamed of performing cholecystostomy in cases of emergency. He should recall that the incidence of accidental ligation of the hepatic artery and especially injuries to the common bile-duct, have increased in frequency (H. K. Gray) as a result of cholecystectomy being performed for acute cholecystitis. The main reason for this is that, especially after 48 hours' duration, œdema often makes the bile-ducts and their associated blood vessels difficult of clear recognition.

The indications for urgent cholecystostomy are :—

1. Fulminating cholecystitis.
2. Acute obstructive cholecystitis. Failure of regression of symptoms and signs within 48 hours.

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[1] Known in the U.S.A. as Demerol.

3. Mucocele of the gall bladder [1]
4. Empyema of the gall bladder
5. Diagnosis uncertain. Acute inflammation of the gall bladder found.
6. Perforation of the gall bladder
7. Stone impacted in the common bile-duct, and cholangitis and cholæmia threatening life.

Operations on the gall-bladder are made easier by having a sandbag under the back about the level of the 11th dorsal vertebra. Most operating tables are provided with a movable bridge (*Fig* 302), which is much more convenient. It is important to see that

Fig. 302.—The gall-bladder position showing the bridge of the operating table elevated.

the patient is in the correct position for this bridge to function *before* the operation is commenced. The adoption of this position is seldom required for cholecystostomy It is, however a useful stand by

Cholecystostomy can be performed through the midline incision sometimes readily but no one would choose this incision if the pre-operative diagnosis was assured because if the patient is fat, the gall bladder small, and the anæsthetic troublesome the operation can be distinctly difficult by this route A vertical incision over the right rectus, splitting that muscle provides excellent exposure of the gall-bladder By this route the abdomen is more easily and more quickly opened, and certainly more readily closed, than by a paramedian incision, especially the anæsthetic is not all that it should be Another advantage of splitting the rectus muscle is that a direct path to the surface is available for the cholecystostomy tube

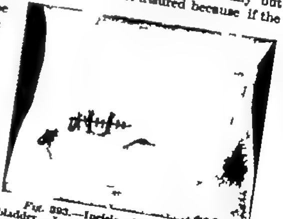


Fig. 303.—Incision for draining the gall-bladder In this case in addition to cholecystostomy the right kidney pouch was drained through a stab incision in the flank.

The limited transverse incision (*Fig* 303) is especially recommended for cholecystostomy when the diagnosis is certain. It gives good access to the gall bladder and it does not disturb Nature's barriers around the seat of infection. Local anæsthesia can be employed for this incision with perfect satisfaction.

The Transverse Incision —The fundus of the gall-bladder may be surprisingly low Always palpate the abdomen before making the incision. Directly over the fundus, if the gall-bladder is distended, or over the anatomical surface marking, an incision is made designed to transect at right angles the right rectus muscle Towels are clipped to the skin edges. The rectus sheath is divided in the length of the incision and the fibres of the rectus are displayed.

[1] Cholecystectomy usually to be preferred.

CHOLECYSTOSTOMY

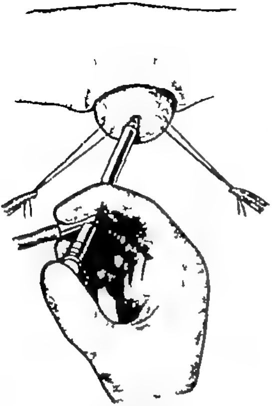


Fig 394 —Cholecystostomy Moynihan's method of isolating the fundus of the gall-bladder A distended gall bladder is first punctured with a trocar and cannula, and its fluid contents are permitted to escape

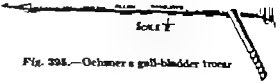


Fig. 395.—Ochsner's gall-bladder trocar

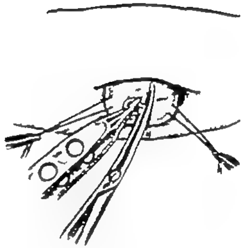


Fig 396.—The puncture hole is enlarged by excising a crescentic portion of the fundus.

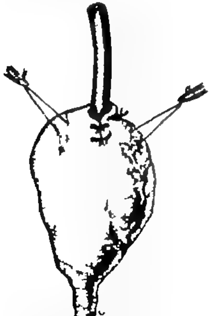


Fig. 397 —When the gall-bladder is thick and œdematous, the incision is closed about the tube by interrupted stitches.

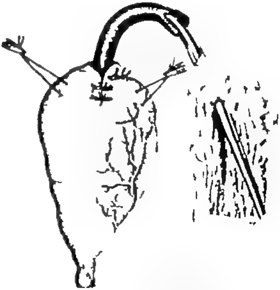


Fig 398.—The tube is then brought through a convenient portion of the greater omentum, which reinforces the suture line.

With light touches of the scalpel or the diathermy needle the muscle-fibres are sectioned a few at a time keeping strictly in the transverse plane. Sometimes there is hardly a vessel to ligate usually the deep epigastric vessels require attention and a ligature on a needle is the best method of securing a bleeding vessel in muscle.

Having located the diseased gall bladder and freed any adhesions thereto a moist abdominal pack is tucked below the gall bladder If the operating table is provided with a movable bridge, instructions can be given at this stage for it to be raised if necessary

A small hole is cut in the centre of an abdominal pack and through this hole the fundus of the gall bladder is made to appear The pad fits snugly around the organ, and when the viscus is opened, infected bile is prevented from running down and soiling the peritoneum. Puncture of the gall bladder is the next step Any attempt to grasp the tense and inflamed gall bladder with instruments will result in tearing of its friable wall Place two stay sutures through the fundus of the gall bladder They will steady the organ efficiently while the trocar and cannula (*Fig* 395), with a sharp thrust, penetrates the fundus.

When the fluid contents have ceased to flow the cannula is removed and the opening in the fundus is enlarged by excision of a crescentic portion of the wall (*Fig* 396) The edges of the incision having been grasped by haemostats, stones are removed from the interior (*Fig* 399). Unless the calculi are very small, fenestrated forceps are better adapted to this work than a scoop The fingers of the left hand beneath the pad may aid in the removal of the calculi by milking them from the region of Hartmann's pouch towards the open jaws of the forceps After the gall-bladder has been emptied of stones, and if time permits, it is a good practice to pass strips of gauze into the interior of the organ until it is dry Minute calculi are often dislodged by this means. A ¼-in. (6-mm.) drainage tube with a lateral opening is then passed down into the body of the gall bladder and is retained in position by a single catgut stitch passing through the cut edge of the viscus. The gall bladder is closed about the tube (*Fig* 397) In large inflamed gall bladders with thick friable walls a purse-string suture simply cuts out. In such cases the junction between the tube and the gall bladder wall must be made as perfect as possible by the introduction of interrupted sutures, two of which usually suffice. The tube is then brought through a convenient piece of omentum (*Fig* 398), which thus comes to rest upon and reinforces the suture line. The stay sutures referred to earlier in this description are brought through the omental covering and finally through the peritoneum before they are tied thereby anchoring the fundus of the gall-bladder to the abdominal wall. If a midline or paramedian incision has been used, a stab incision is made over the gall bladder and the tube is brought out through this. If the rectus has been split, or a transverse incision has been made, the tube is brought directly through the incision at a convenient spot in which case the peritoneum must be carefully and independently approximated about the tube After the abdomen has been closed, the tube is brought directly through the dressings, and when the patient has been returned to bed, it is connected to a bottle for collecting the bile (*Fig* 400).

Fig. 399 —Cholecystostomy Extracting a stone with fenestrated forceps. A scoop is also a useful instrument for this purpose

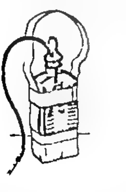


Fig 400.—A medicine bottle a rubber teat and adhesive plaster make a good sterile receptacle for bile (*After H I Cameron*)

CHOLECYSTECTOMY

A number of surgeons advocate early cholecystectomy for acute cholecystitis. By *early* cholecystectomy is meant 4–8 hours are expended in adjusting electrolytic balance the administration of antibiotics, and carrying out other necessary pre-operative measures.

Provided the operation is carried out within 48 hours of the commencement of the attack, the technical difficulties and mortality of the operation, especially in patients under 50 years of age, is low However the general mortality figures are no better than, if as good as, those obtained by vigilant delayed treatment plus cholecystostomy in cases where that treatment fails to bring about resolution.

After a wave of enthusiasm for early cholecystectomy some surgeons of experience in Great Britain the U.S.A., Europe and Soviet Russia are returning to the Ochsner Sherren treatment, or to early cholecystostomy Their reasons for this change are reviewed at some length in Chapter XCIV In this chapter the opinion is expressed that when the surgeon is *inexperienced in performing cholecystectomy* it is unwise to undertake this operation as an emergency measure if an alternative procedure is available. As a rule, when urgent operation on the gall-bladder is imperative, cholecystostomy will save life. There are, however a few instances where urgent cholecystectomy is the method of choice, and they are set out in the pages that follow immediately Eventually 6–8 weeks *after the termination of the acute attack*, unless there is some definite contra indication to a major operation, cholecystectomy is performed in the quiescent stage

Technique—Standard cholecystectomy and cholecystectomy by Thorek s method differ only in one essential particular In standard cholecystectomy the gall-bladder is removed *in toto* In Thorek s cholecystectomy that portion of the gall-bladder attached to the liver and that portion only is left attached and its mucosa destroyed by electro-coagulation. By *allowing* this strip of the gall bladder to remain the integrity of the liver as an encapsulated organ is preserved.

The incision is a matter of individual choice A transverse incision over both recti (*see* p 162) gives excellent exposure. If there is uncertainty about the diagnosis, the paramedian incision has much to offer The gall-bladder is emptied by aspiration. The cystic duct and cystic artery are exposed by dissection, and divided between ligatures, as in the standard operation. A good guide by which to locate the cystic artery is the cystic lymph-node (*Fig* 401). When the gall-bladder is in an acutely inflamed state it is doubly necessary to direct and demonstrate clearly the cystic, the common hepatic and the common bile-ducts (*Fig* 402) before dividing the duct. If, as is sometimes the case œdema prevents this demonstration, it is safer to abandon the more radical treatment in favour of cholecystostomy

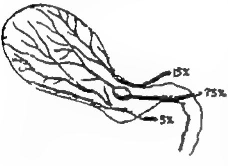


Fig 401 —The relationship of the cystic artery to the cystic lymph-node (*After Ramirez Flores.*)

The fluid content of the gall bladder is aspirated. Having isolated the area with abdominal packs carefully the gall-bladder is split longitudinally (*Fig* 403) The stones are allowed to fall into Thorek s bile receptacle, or if this is not available a tablespoon will answer the purpose. The redundant portion of the walls of the gall-bladder is excised with scissors or the diathermy knife. The posterior wall of the gall-bladder which remains attached to the liver is then treated by electrocoagulation (*Fig* 404). The current should be turned on only when the ball electrode is firmly in contact with the tissues, so as to avoid fulguration. When the posterior wall of the gall-bladder has been electrocoagulated its edges are approximated with catgut sutures; the sewing needle should not penetrate the liver substance A detached portion of the falciform ligament or a free omental graft is stitched over the sutured remnant of the gall bladder (*Fig* 405)

The advisability of exploring the common bile-duct.—If there is a history of jaundice or if the common bile-duct appears dilated or feels thickened, or a stone or stones can be palpated therein, provided the condition of the patient is good, it is essential to explore the common bile-duct (*see* p. 323), after which this duct must be drained with a T tube After inspecting the area thoroughly to ensure that hæmostasis is perfect the abdomen is closed with local corrugated rubber drainage Some omit drainage altogether but a soft drain does no harm, and in the rare event of post-operative hæmorrhage the blood is directed externally

Fig. 402.—The junction of the cystic, common hepatic, and common bile-ducts has been displayed; the cystic artery has been clamped and divided.

Fig. 403.—The gall-bladder is split open and the contents evacuated into Thorek's receptacle. Packs are omitted for the sake of clarity

Fig. 404.—The redundant portion of the walls of the gall-bladder having been excised, that part of the gall-bladder which remains attached to the liver is electro-coagulated

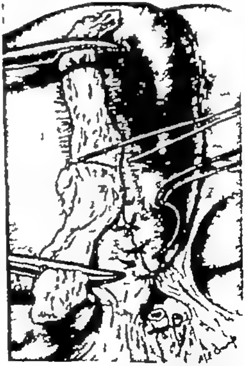


Fig. 405.—The detached falciform ligament of the liver or a piece of omentum, is sutured over the gall-bladder bed.

THE CONTROL OF ACCIDENTAL HÆMORRHAGE FROM THE CYSTIC ARTERY

The principle involved is to control the cystic artery by compression of the hepatic artery (*Fig* 406). This can be done by placing a finger through the foramen of Winslow and the thumb overlying the free edge of the gastrohepatic omentum. When the foramen of Winslow is non-existent, the free edge of the gastrohepatic omentum is grasped *en masse* or the vessels are compressed against the vertebral column. If the hand occupies too much room, the incision can be enlarged whilst the hepatic artery is being compressed. After the field has been mopped dry by momentarily relaxing pressure on the hepatic artery the bleeding cystic artery can be located accurately caught in forceps, and ligatured

Fig 406.—Compressing the free edge of the gastrohepatic omentum in order to control hæmorrhage from the cystic artery (*Hogarth Pringle's method.*)

Post-operative Hæmorrhage.—If drainage has been employed, the hæmorrhage will be apparent, which is an argument in favour of drainage Provided that hæmorrhage is severe and leaves no doubt that the vessel is spurting it is necessary to reopen the abdomen. It is important to have the patient in the gall bladder position (*see Fig* 392). The cystic artery may be proved culpable or innocent by compressing the hepatic artery and if the hæmorrhage continues in spite of this procedure the bleeding point must be looked for elsewhere

ACUTE CHOLECYSTITIS

Ninety-six per cent of patients with acute cholecystitis have stones in the gall-bladder. By far the commonest single cause of acute cholecystitis is obstruction by a stone impacted in the neck of the gall-bladder (*Fig* 407) or in the cystic duct. Acute non-calculous cholecystitis occurs *on rare occasions, sometimes in the course of* an acute infectious disease such as pneumonia, typhoid, or virulent influenza.

Diagnosis.—The onset is often sudden and the pain is usually severe After a variable period (usually two or three hours) biliary colic is superseded by a dull, throbbing pain localized in the right hypochondrium. Nausea, retching, and vomiting together with belching of large quantities of gas, a rise of temperature (in 60 per cent of cases the temperature is above 100 F (37 7° C.)) and an elevated pulse-rate are characteristic features. Tenderness and rigidity can be elicited in the right hypochondrium and Murphy's sign is present. Jaundice occurs in about 23 per cent of cases. In the majority of cases it seems likely that jaundice in acute cholecystitis is due to hepatitis, because so often it can be proved later that the common bile-duct is free from obstruction on the other hand a stone or stones will be found in the common bile-duct in 20 per cent of cases.

Fig 407 — Acute obstructn cholecystitis.

A palpable, tender gall bladder perhaps the clearest positive physical finding becomes manifest at some time in the clinical course in 45 per cent of cases.

In many instances the diagnosis presents no particular difficulty In others right-sided pyelonephritis must be excluded. High retrocæcal appendicitis not infrequently proves an insuperable stumbling block, and in cases of under 48 hours duration laparotomy is advised.

Whenever possible a *serum-amylase estimation* should be undertaken, for the symptoms of acute pancreatitis and acute cholecystitis are often similar Indeed, the two conditions can be present concurrently

The condition which is the most difficult to differentiate from acute cholecystitis is a myocardial infarct (coronary thrombosis). While electrocardiographic examination is most desirable whenever this differential diagnosis has to be made In actual fact an abnormal

electrocardiograph in an elderly patient who has had already severe cardiac disease is of little diagnostic value

Radiography.—A plain radiograph is advisable at any rate it will exclude gas beneath the diaphragm. In 14 per cent of cases, usually thin subjects, and especially in children, radio-opaque calculi are displayed in the gall bladder In rare instances gaseous cholecystitis (see p 315) is revealed.

Treatment.—Acute cholecystitis is not an indication for immediate operation. As a rule intelligent inactivity during the attack and cholecystectomy after the attack has subsided, is safer and better in every way No one who has observed the regularity with which these cases respond to expectant treatment would wish to interfere with Nature's reparative process during the acute stage Cholecystectomy performed after the attack has subsided carries a low mortality and rids the patient of an organ which is almost certainly irreparably damaged and likely to give rise to further trouble.

If operation is performed between the third and ninth days, the mortality rises. In this respect acute cholecystitis is not unlike appendicitis in that there is a time at which the operation (cholecystectomy) is hazardous (Alton Ochsner)

Delayed Treatment.—In many respects the details of the treatment are similar to those of the Ochsner Sherren treatment of appendicitis (see p. 252) constant vigil must be maintained for progression of symptoms and signs that foretell failure of the treatment. The patient is placed in Fowler's position, and for the first 24–48 hours continuous intravenous dextrose-saline solution is administered. During this period nothing is given by mouth. If vomiting has been in evidence, the stomach must be emptied, and kept empty by means of an indwelling gastric aspiration tube. The local application of heat, in the form of an electric heating pad, is comforting If the patient is even slightly jaundiced, vitamin K should be administered in addition to vitamins B and C, which are given as a routine. For the relief of pain pethidine 2 ml. (100 mg) is given intravenously and can be repeated four hourly as necessary If severe unrelenting pain, as opposed to tenderness, persists for more than 48 hours, operation should be advised.

Antibiotic Therapy.—It has been shown that antibiotics of the tetracycline group (aureomycin and terramycin) reach the interior of the gall bladder via the blood-stream, even in the presence of occlusion of the cystic duct. For this reason Pulaski and Fusillo recommend that in cases of acute cholecystitis an antibiotic of the tetracycline group should be given from the commencement. In the initial stages doses of 1–1 5 G are given intravenously bis die but, because of the liability of repeated injections to cause thrombophlebitis, oral administration should be commenced soon after the patient is permitted to take fluids by mouth.

Further Details of the Delayed Treatment.—When the rigidity has passed off *if a lump (the gall-bladder) is palpable* in the right hypochondrium its boundaries are marked on the skin. After the daily examination the fact as to whether the lump is stationary or is decreasing or increasing in size must be recorded in the notes. Increase in size is an indication for abandoning delayed treatment.

Often, after 24–48 hours, small dextrose drinks are allowed. When the pulse, temperature, and other physical signs show that the inflammation is subsiding the parenteral administration of fluid can be stopped, and the oral intake increased. After the bowels have been opened by an enema, a milk diet can be commenced.

In the great majority of cases complete clinical resolution occurs within 10–14 days. After cholecystography has been performed the patient can be discharged home on a fat poor diet, and instructed to return in 6–8 weeks for interval cholecystectomy In cases where resolution occurs quickly the interval can be shortened to three or four weeks, but this is not recommended because acute cholecystitis takes months to resolve in spite of the fact that the patient is symptom-free. In those patients who have had previous attacks, and have refused operation, if consent is given cholecystectomy should be performed before the patient is permitted to return home.

The delayed treatment of acute cholecystitis stipulates accurate and confident diagnosis. If we are sure that the case is one of acute cholecystitis, it is seldom necessary to open the abdomen for several weeks. If we cannot exclude perforated ulcer or high retrocæcal acute appendicitis of under forty-eight hours duration, it is essential to operate From time to time exploration is the only course and if an acute cholecystitis is found, the gall-bladder must be drained or removed. Following this régime the number of cases submitted to immediate operation will be inversely proportional to our diagnostic ability

Very occasionally whilst undergoing expectant treatment, the patient will have a recrudescence of symptoms. A return of the pain, vomiting and a rise in pulse-rate indicate failure of the treatment. Perforation of the gall bladder from acute obstructive cholecystitis is not very rare, but perforation of the gall-bladder *while the patient is under delayed treatment* for acute cholecystitis is most exceptional. There is no denying that it is possible for perforation to occur under these conditions, but with the patient under the direct observation of the surgeon, who is able to operate without delay even this exceedingly rare complication should seldom prove fatal.

To recapitulate The danger of perforation whilst the patient is under a strict régime is an infinitely small one Should it occur it is by no means necessarily fatal if recognized promptly which it should be with the patient under the conditions laid down here. To recommend immediate operation in acute cholecystitis on the ground of possible perforation is unjustifiable. No one would dream of recommending immediate operation during one of the acute exacerbations of a chronic duodenal ulcer on the ground that the ulcer might perforate. Uncertainty of diagnosis remains the chief indication for very urgent gall bladder surgery

Delayed Treatment is not Advised.—

1 When there is uncertainty about the diagnosis, e.g., early high retrocæcal appendicitis or a leaking duodenal ulcer cannot be excluded.

2. The presence of considerable diabetes is an indication for early operation.

3. Pregnancy makes operation necessary

4 An uncompensated cardiac lesion and renal disease is further burdened by sever infection, and early operation is advised.

In the last three contingencies 3–6 hours are spent in getting the patient into the best possible condition for operation.

Delayed Treatment must be Abandoned.—

1 If after a period of 24–30 hours, the pulse-rate and temperature are not falling the pain persists, and the physical signs point to an *empyema of the gall-bladder* operation should be undertaken forthwith, as also if there is a recrudescence of symptoms after a period of quiescence.

2. When the absence of pyrexia and the presence of a large piriform swelling in the right hypochondrium make the diagnosis of *mucocele of the gall-bladder* probable, after excretory pyelography has been performed to exclude a right hydronephrosis, operation is best carried out in a matter of hours.

3. When a gall-bladder *perforates into the general peritoneal cavity* urgent drainage of the peritoneal cavity and the gall-bladder is imperative after such treatment 60 per cent of the patients recover without immediate operation, the mortality approaches 100 per cent. As pointed out already this complication is exceedingly rare in patients undergoing the delayed treatment of acute cholecystitis.

4 Typhoid fever is rare except in tropical countries. Because of the danger of perforation in *acute typhoid cholecystitis* very early operation must always be advised.

Although this list of indications for abandoning delayed treatment may appear formidable, uneventful resolution occurs in 85 per cent of patients with acute cholecystitis.

Subsequent Cholecystectomy.—Six to eight weeks after the termination of an episode of acute cholecystitis treated either by the delayed method or by cholecystostomy because of the high incidence of recurrence cholecystectomy should, if possible be insisted upon. In cases where cholecystostomy has been performed, the surrounding adhesions, although often considerable, are not greater than in many cases where a previous operation has not been performed, especially if a barrier of easily divided greater omentum has been placed over the fundus of the gall bladder as recommended in this chapter

ACUTE CHOLECYSTITIS FOLLOWING OPERATION FOR UNRELATED DISEASE

The recognition of acute cholecystitis occurring in the post-operative period is often difficult, and the symptoms are frequently mistaken for usual post-operative sequelæ The first symptoms often occur within 48 hours of resumption of feeding Even palpation at laparotomy of what seems to be a normal gall-bladder is no guarantee against its later acute inflammation. In only 8 of Glenn's 17 cases did the cholecystitis follow an intraperitoneal

operation. Clearly surgeons should remember that acute cholecystitis is an uncommon, though none the less serious, complication following operations for completely unrelated diseases.

ACUTE FULMINATING CHOLECYSTITIS

Very few cases of acute cholecystitis fail to respond quickly to the non-operative régime described in this chapter

The following case is an exception —

After his evening repast a solicitor was seized with acute pain in the right hypochondrium. There was no particular difficulty about the diagnosis, for the rigidity was localized and his temperature was over 103° F (40° C.). The hourly pulse-rate during the night showed a steady increase. In the early hours of the morning he had a rigor and, contrary to most cases of acute cholecystitis, his facies was that of a very sick man. At 10 a.m., after he had had sufficient dextrose-saline solution intravenously the abdomen was opened, using the limited transverse incision. The gall-bladder which was only moderately enlarged, was very tense and of a dusky mottled appearance. Momentarily I wondered if cholecystectomy would be the right course, for so virulent a focus might well lead to spreading peritonitis. The œdema about the cystic duct and the report from the anæsthetist that the patient s condition was poor negatived this course. On puncturing the gall-bladder thin blood-stained pus came out. There was a solitary calculus wedged in the entrance of the cystic duct ; the stone was removed by the method shown in *Fig* 411 Cholecystostomy was performed. The pulse-rate remained unduly fast for several days, but steady improvement in the general condition was maintained. Six months later cholecystectomy was performed.

ACUTE GASEOUS CHOLECYSTITIS

There is a gross accumulation of gas within the lumen and within the wall of the gall bladder frequently extending into the tissues around the gall bladder The patient is often a diabetic. The signs and symptoms are those of severe acute cholecystitis. After about 48 hours the radiograph discloses a dark pear-shaped shadow of gas outlining the usually distended gall-bladder with its walls demarcated by contained gas as a darker circumferential shadow The biliary ducts and radicles are usually not outlined. Gas-producing organisms, e.g *Cl perfringens*, may exist for a long time in the bile and the wall of the gall-bladder without producing symptoms. When obstruction of the cystic duct arises, they rapidly become pathogenic, producing gas infection. At operation crepitation can be elicited in the wall of the gall-bladder gas and malodorous exudate is present within the gall-bladder the mucosa is often partially or completely separated from the muscular layer and is gangrenous. If the patient is not extremely ill, in the presence of mucosal gangrene it would seem to be best to perform cholecystectomy but cholecystostomy has saved lives in this condition.

MUCOCELE (HYDROPS) OF THE GALL-BLADDER

Without exception this is due to a stone becoming impacted in the cystic duct. As a rule, the condition is neither difficult to diagnose nor is it desperately urgent. On the other hand, it must be realized that it is impossible to define where a mucocele ends and an empyema of the gall-bladder begins. Furthermore, a palpable gall bladder with a recent sudden onset of pain should be looked upon as a manifestation of *acute obstructive cholecystitis* a condition in which tension gangrene may proceed apace.

It is most unwise to allow a large, tender mass, presumably the gall bladder that does not decrease in size to remain unexplored for more than 24 hours. In such cases one should have in mind the following concept —

ACUTE OBSTRUCTION TO THE CYSTIC DUCT + INFLAMMATION
↓
INCREASED TENSION WITHIN THE GALL-BLADDER
↓
DIMINISHED VASCULAR SUPPLY
↓
TENSION GANGRENE
↓
PERFORATION

A. Y., aged 54 had violent right-sided colic during the night When seen at dawn the patient was sitting up in bed quite comfortably and the result of my clinical findings are shown in Fig. 408. It was agreed that excretory pyelography would settle the diagnosis. The pyelogram showed a normal kidney outline with the exception of an opacity at the uretero-pelvic junction (*Fig 409*) It was argued that this opacity must be an artefact, because the kidney was obviously functioning If the swelling was the right kidney a normal outline of the renal pelvis and calices was impossible That evening the patient said he felt quite well, but the lump was

Fig 408.—Facsimile of the diagram which accompanied the notes of A. Y.

Fig 409 —Excretory pyelogram of patient A Y., showing the artefact at the pelvi-ureteric junction.

still in evidence, and his temperature was now 99 F (37° C.). Early the following morning laparotomy was performed. On puncturing the enormous gall-bladder thick mucopus slowly exuded. A hand was passed beneath the towel, in order to palpate the neck of the gall-bladder and by compression to speed up the flow The manipulation was of the gentlest character but it caused the gall-bladder to burst at Hartmann's pouch. Fully three-quarters of a pint of mucopus was liberated, but the surrounding area was well packed off. The fluid was too thick to be aspirated with a sucker and it was mopped up with abdominal packs. It was then seen that a large stone had come through the perforation. The gall-bladder was slit from the perforation to the fundus. The mucous membrane was of a dusky hue and in the region of the perforation it was green and gangrenous (*Fig* 410). On palpating the cystic duct it was ascertained that there was a stone the size of a pea tightly impacted therein this was removed with a small Volkmann's spoon breaking the stone in the process. Desjardins forceps were passed down the cystic duct into the common bile-duct and clear bile flowed from the open mouth of the cystic duct. The cystic duct was ligated and cholecystectomy performed by Thorek s technique A small drainage tube was left in position because of the local soiling of the peritoneum referred to. The patient recovered uneventfully

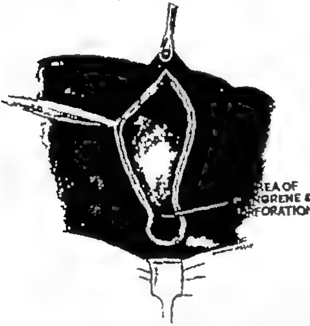


Fig. 410.—The gall-bladder was slit up from the perforation in Hartmann pouch to the fundus. Showing the gangrenous interior

EMPYEMA OF THE GALL-BLADDER

The temperature is a notoriously unreliable guide in many of these cases, and although there is no desperate hurry the sooner the pus is evacuated the better In general it can be stated that it is usually in the patient s interests to spend 12–24 hours in getting her into the best possible condition for the operation, a high dextrose intake being an important consideration in this respect. Should the pulse advance even a few points during this interval, the performance of the operation must be expedited.

The limited transverse incision is particularly valuable in this instance, for the area of the gall-bladder can be well packed off, which is so desirable After the pus has been

evacuated, almost without exception, a stone will be felt impacted in the commencement of the cystic duct occasionally this is the only stone present. By judicious upward pressure with the finger and thumb (*Fig* 411) the stone can often be expressed into the more commodious region of the neck of the gall bladder where it can be retrieved and removed. Disimpaction of this, the keystone of the trouble, is desirable though not vital. If this stone remains the patient usually recovers, but a persistent mucopurulent fistula remains until at a second operation cholecystectomy is performed.

There are occasions when the diagnosis of empyema of the gall-bladder is difficult, for the gall bladder is so embedded in adhesions as to make it impalpable. For the same reason it is sometimes extremely difficult to find the gall bladder at operation even with adequate exposure

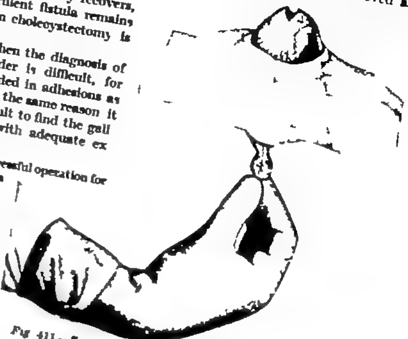


Fig 411 —Squeezing a stone impacted in the cystic duct into the neck of the gall-bladder

A. L., aged 72, had had a successful operation for strangulated left inguinal hernia performed six months previously During convalescence he complained of pain in the right loin but nothing was found to account for it He returned home and the pain became worse he always had pain in his back, but it was more in evidence on some days than others. For the last six weeks the pain had been very severe and continuous. The signs seemed to point to right renal pain and although he was tender in the hypochondrium, his doctor stated that during the time he was under observation his temperature had never been elevated more than 99 F (37° C.). After he had been removed to hospital, excretory pyelography showed that the right kidney was functioning. It was therefore decided to explore the gall-bladder allowing two days to get the patient as fit as possible. Under local anaesthesia the abdomen was opened through a transverse incision. Where the fundus of the gall-bladder should have been there was a segment of small intestine adherent to the liver This was dissected free with difficulty but there was still no sign of the fundus of the gall-bladder

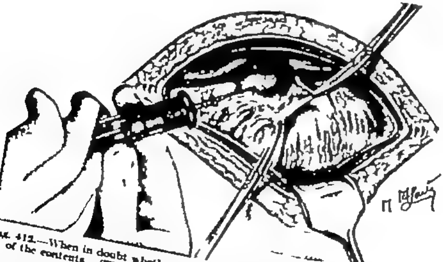


Fig. 412.—When in doubt whether a structure is the gall-bladder aspirate some of the contents. (This advice also holds good for the common bile-duct.)

Continuing to dissect omentum from the free edges of the liver at length a small portion some hollow viscus was displayed. In order to ascertain whether this was the fundus of the ga bladder a hollow needle was inserted (*Fig* 412) and thick pus was withdrawn. Cholecystostom was then performed and about a quarter of a pint of stinking pus was evacuated. A stone w expressed from the neck of the gall-bladder and other calculi removed. The operation w completed in the manner described on page 309 After a rather stormy convalescence the patien made a good recovery

TORSION OF A FLOATING GALL-BLADDER

A prerequisite of this condition is an unusual anatomical arrangement whereby th gall bladder is suspended by a mesentery long enough to allow the gall-bladder to hang fre in the peritoneal cavity Torsion o the gall bladder is a rare condition about 100 cases have been reported

Fig 413.—Torsion of the gall-bladder Cholecystectomy is extremely simple as will be appreciated by observing this typical pedicle (*Rendle Short and Paul, "British Journal of Surgery"*)

Should a greatly enlarged gall-bladder be palpable within a few hours of the onset of an attack of biliary colic the possibility of torsion of the gall-bladder should come to mind. In such circumstances it is important not to delay operation on the supposition that the symptoms and signs are due to cholecystitis. The statistical studies of Rendle Short and Paul showed that patients with this condition, even though they are advanced in years, recover if operation is undertaken within 48 hours.

Most of the cases reported have occurred in elderly women.

A. H Barber's Case —

A warehouseman, aged 44, w seized with very severe abdomi pain in the upper right abdomen on t previous day Vomiting was pe sistent. The physical signs point to a perforated peptic ulcer (opening the abdomen a considerab amount of blood-stained fluid w found and the gall bladder was di tended to about the size of an orang and was of a deep blue-black hue The whole gall-bladder was completely covered with per toneum and suspended from the anterior border of the liver by the cystic duct and vesse Cholecystectomy was therefore extremely simple all that was necessary was to ligate the pedic below the twist before severing the gall-bladder from its only attachment.

Owing to the anatomical arrangement which allows torsion of the gall-bladder to occu (*Fig* 413), cholecystectomy is a procedure of simplicity

EXTRAVASATION OF BILE (BILE PERITONITIS)

If on opening the peritoneum pure bile is found the following four conditions mu be thought of —

1 Perforation of the gall bladder
2. Perforation of the bile-ducts.
3. Perforated duodenal ulcer (second part of the duodenum).
4 Spontaneous biliary peritonitis.

It is therefore necessary to examine the gall-bladder the bile-ducts, and the fir and second parts of the duodenum. In the event of a perforation remaining undiscover after searching for a reasonable time (in accordance with the condition of the patient) th possibility of (4) should be assumed.

When bile is found in the peritoneal cavity following an abdominal accident the following three conditions must be borne in mind :—

1 Rupture of the gall-bladder (*see* p. 388).
2. Rupture of the common bile-duct or hepatic duct (*see* p. 389)
3. Rupture of the duodenum (*see* p. 381).

Post-operative bile peritonitis is discussed on p. 214.

Bile peritonitis causes rapid and profound toxæmia—general symptoms of peritonitis out of all proportion to what one would expect. If the bile is drained from the peritoneal cavity early enough dramatic improvement often occurs.

FREE PERFORATION OF THE GALL-BLADDER

Further evidence that while widespread bile peritonitis is very lethal it is also a condition which responds to prompt surgical treatment, is afforded by C. A. McWilliams s study of 48 cases of free perforation of the gall-bladder

Of 7 cases operated on within	12 hours	6 recovered	(14 per cent mortality)
Of 15 ,,	24 ,,	10	(33 per cent ,,)
Of 16 ,, ,,	3 days	8	(50 per cent ,,)
Of 10 ,, ,,	4	4 ,,	(60 per cent ,,)

Difficulties in Diagnosis.—Unless we know that the patient has suffered recently with gall-stones or cholecystitis, the diagnosis is almost impossible. In the absence of such data the nearest approach to a correct pre-operative diagnosis will be that perforation of a duodenal ulcer has occurred. On the other hand, with a lead, the problem is not by any means insuperable.

A. H aged 42, was admitted with a large tender swelling coming from beneath the right costal margin. The symptoms had been present for five days, but after the first few hours the pain had not been severe. Excretory pyelography showed a normal pelvis of the right kidney which heightened the suggestion that the swelling was a greatly distended gall-bladder Two days later while his abdomen was being prepared for laparotomy he experienced a severe attack of pain which soon passed off The pulse rate, which had been normal, began to rise On examining his perfectly flaccid abdomen I was astounded to find that the large lump had disappeared completely On opening the abdomen free bile was found in the peritoneal cavity There was a large perforation in the gall-bladder just above Hartmann's pouch, and beneath this two gall-stones lay free. Cholecystectomy with local and suprapubic drainage was carried out. Convalescence was uneventful.

Operation.—When the organ is examined, the perforation is not difficult to find. Its situation varies; it may be at the fundus, or at Hartmann s pouch, or between the two (*Fig* 414). If the opening is at the fundus, it should be enlarged, the stones removed, and cholecystostomy performed. If the perforation is further down, the gall bladder may be slit up towards the fundus. After clearing the interior of stones and debris the gall bladder may be reconstructed around a drainage tube. Alternatively if the patient s general condition permits and the operator is experienced in the technique, cholecystectomy is permissible

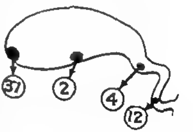


Fig 414 —The sit of the perforation in 50 cases. In 4 of these there was more than one perforation. (*Pines and Rabinovitch s statistics.*)

Drainage of the peritoneum should always be carried out by : (1) Local drainage by a stab wound in the mid-axillary line, about 1½ in. (3 8 cm.) below the costal margin in order to drain Rutherford Morison s pouch ; and (2) Suprapubic drainage in all but very early cases.

Localized Abscess Formation after Perforation of the Gall-bladder—In over 80 per cent of cases the perforation is well localized. The frequency with which localization occurs results from adhesions developing during previous attacks of cholecystitis. Unless the collection of purulent bile is considerable, the diagnosis is indistinguishable from that of empyema of the gall-bladder

F C., aged 60, had been ill for five days. There was a large tender mass beneath the right costal margin, but the overlying rigidity made it impossible to define its limits accurately The temperature was 103 F (40° C.), although he did not appear to be gravely ill. For forty-eight hours he was treated by the delayed method. As the temperature remained at this high level and he was rather worse than better operation was decided upon, the diagnosis being empyema of the

gall-bladder The abdomen was opened by the limited transverse incision described already. As soon as the peritoneum was incised, bile and purulent gelatinous material escaped. A perforation was found in the gall-bladder near the fundus. A solitary calculus impacted in Hartmann's pouch was expressed (*see Fig. 411*). Utilizing the perforation, which admitted the little finger, cholecystostomy was performed and the abscess cavity was drained. Free drainage of bile through the cholecystostomy tube continued for seventeen days the tube was then removed. Convalescence was delayed by retention of urine but a good recovery followed.

It is important to refrain from tearing Nature's barriers, which are usually the great omentum and the transverse colon. If the perforation is inaccessible or other circumstances make it difficult to deal directly with the gall bladder reliance can be placed on simple drainage of the abscess cavity Seven out of eight patients so treated recovered (L. R. Fifield).

PATHOLOGICAL PERFORATION OF THE COMMON BILE-DUCT

A man of 45 whilst walking home from work, was seized with abdominal pain. With difficulty he managed to reach his destination, a quarter of a mile distant, unaided. Twenty-two hours later he was brought to hospital. The temperature was 97° F (35° C.), the pulse 72, and he appeared very shocked and ill. The physical signs were typical of a perforated duodenal ulcer, and as he was a very thin man, shifting dullness could be demonstrated easily

The abdomen was opened by a supra-umbilical midline incision. Pints of bile were found in the peritoneal cavity Bile was also present in the lesser sac and *behind* the peritoneum, which was floated up. *The gall-bladder looked normal, but on palpation many tiny calculi were felt* within. The stomach and duodenum were examined, with a negative result. The cystic duct and supraduodenal portion of the common duct were examined with a seeker but no perforation was demonstrable indeed, these structures appeared quite normal. It was concluded that there was a perforation of some part of the hepatic or common bile-duct. Cholecystostomy and *drainage of the peritoneum was performed. Throughout the operation the patient received saline* infusion, and he was returned to bed in good condition. Next morning his pulse was good and he stated that he felt better It was remarked that it was curious that he showed no signs of jaundice Twelve hours later he collapsed and died. At the necropsy a perforation at the back of the junction of the cystic and common ducts was demonstrated.

I encountered a similar case again I was unable to find the perforation and the case ended fatally If the perforation can be found, it should be enlarged sufficiently to insert a T tube When the perforation cannot be found, provided the patient is in good condition the duodenum and the head of the pancreas should be mobilized (see p. 382) in the endeavour *to find a perforation in the retroduodenal portion of the common bile-duct.* In any case choledochostomy cholecystostomy and peritoneal drainage should be performed.

To drain the common bile-duct with a T tube is absolutely essential without this step the patient nearly always dies. Antibiotic therapy should be commenced at the earliest possible moment.

SPONTANEOUS PERFORATION OF THE COMMON BILE-DUCT AS A SEQUEL OF CHOLEDOCHOSTOMY

Wolfson and Levine have encountered three cases of spontaneous perforation of the common bile-duct following choledochostomy The train of events is as follows The T tube draining the common duct is removed at the appropriate time The patient makes a satisfactory recovery and returns home, but at a period varying from four days to six weeks is re-admitted because of a sudden onset of peritonitis. The abdominal cavity is reopened and *found to contain a tremendous quantity of bile.* Acute pancreatitis is the condition most likely to be confused with this syndrome. It is important to know that spontaneous rupture of the common bile-duct may follow choledochostomy Armed with this knowledge immediate laparotomy will be performed, instead of instituting expectant treatment.

SPONTANEOUS BILE PERITONITIS

Numbers of examples of bile peritonitis, i.e., free bile in the peritoneal cavity without a demonstrable perforation of the biliary tract have been recorded, mostly in the Continental literature. Sir Zachary Cope reporting six personal cases, concluded that the most logical explanation for this remarkable phenomenon was that an acute ulcer in some part of the biliary tree resulted in a minute perforation, through which bile was forced by the normal muscular contractions of the gall-bladder The truth of this hypothesis was substantiated by a case reported by Small who, having

concluded a fruitless search for a perforation, noticed a small area of discoloration in the sulcus between the gall-bladder and the liver. In the centre of this area was a minute perforation. Immediately following the perforation, like that of the intestine, there is cessation of peristalsis and the patient may have but few symptoms. Intestinal activity returns after the stimulation caused by the ingestion of food. Bile is then forced through the perforation, and signs of peritonitis become obvious.

Spontaneous bile peritonitis cannot be diagnosed before laparotomy; even then it gives rise to considerable confusion, if the surgeon is unaware of the existence of this rare clinical entity. Early cases simulate a perforated peptic ulcer *although the symptoms are not so acute* (S. Power). Late cases present the features of diffuse peritonitis.

From a practical standpoint, the position is this. The abdomen is opened: pure bile is discovered therein. The gall-bladder appears and feels normal: no stones can be palpated in the biliary tree. It is ascertained that there is not a perforation of the duodenum. In such circumstances suck out the bile, if a sucker is available, and perform cholecystostomy. Drain Rutherford Morison's pouch, and when there is a considerable quantity of bile in the general peritoneal cavity insert a tube into the rectovesical pouch through a suprapubic incision. Close the abdomen as quickly as possible. In all cases give dextrose-saline, dextran, or plasma and, when available, blood transfusion, according to the needs of the patient.

The mortality is very high; at least 60 per cent of patients with this condition die. Probably with gentle, swift surgery the mortality could be lowered. The trouble is that because the condition is so rare, few surgeons are aware of its existence. Consequently a great deal of time is wasted in searching for a perforation and the resulting operative trauma is not inconsiderable.

Spontaneous Bile Peritonitis in Infancy.—Owing largely to delay in diagnosis, the prognosis of bile peritonitis in infancy is very poor. A pre-operative diagnosis can sometimes be made with assurance by paracentesis. In three cases reported recently simple drainage proved successful.

In Davies and Elliot-Smith's case bile was seen issuing from a perforation in a greatly distended common bile-duct: the cause of the distension was congenital atresia of the duct. The perforation was enlarged, and the opening was anastomosed to the duodenum. The peritoneum was drained. Recovery followed.

Post-operative Bile Peritonitis.—(*See* p. 214.)

Traumatic Bile Peritonitis.—(*See* p. 389.)

OBSTRUCTIVE JAUNDICE

Most of the conditions dealt with in this work are urgent in the sense that there are but hours—sometimes, indeed, only minutes—in which to act. Obstructive jaundice can hardly be placed in this category, yet it cannot be omitted.

When the jaundice *is not deep the question of early operation does not arise*: the patient is observed from day to day. If the jaundice is clearing and the cause is probably or definitely gall-stones, operation should be postponed for at least a week or until the jaundice has cleared completely. If the jaundice is getting deeper, if when the patient is first seen, it is already of an olive hue, and particularly if the jaundice has been progressive and the onset painless, operation should be arranged for in two or three days' time. During the interval active preparations (*see below*) are made.

Causes of Obstructive Jaundice.—

1. Gall-stone in the common bile-duct.
2. Carcinoma of the head of the pancreas.
3. Subacute or chronic pancreatitis obstructing the ampulla of Vater.
4. Simple stricture of the bile-ducts.
5. Malignant stricture of the common duct.
6. Metastatic carcinomatous deposits obstructing some part of the biliary system.

It is not proposed to enter into the differential diagnosis of these various types of obstructive jaundice, the salient features of which are well known. In spite of better understanding of the principles which govern this differential diagnosis, there are many surprises in this branch of surgery—happily sometimes pleasant surprises. Take, for instance, the patient illustrated in *Fig.* 415. The enlarged, somewhat irregular liver combined with deep progressive jaundice, caused a competent observer to diagnose malignant disease in spite of the fact that the trouble started with an acute attack of pain. Unwisely, the patient was ordered cholecystography. As might be expected, the cholecystogram showed nothing but the additional strain on the liver in endeavouring to excrete the dye caused him to pass into a semi-comatose condition. After a blood transfusion,

gall-bladder. The abdomen was opened by the limited transverse incision described already. As soon as the peritoneum was incised, bile and purulent gelatinous material escaped. A perforation was found in the gall-bladder near the fundus. A solitary calculus impacted in Hartmann's pouch was expressed (*see Fig.* 411). Utilizing the perforation, which admitted the little finger, cholecystostomy was performed and the abscess cavity was drained. Free drainage of bile through the cholecystostomy tube continued for seventeen days; the tube was then removed. Convalescence was delayed by retention of urine, but a good recovery followed.

It is important to refrain from tearing Nature's barriers, which are usually the great omentum and the transverse colon. If the perforation is inaccessible or other circumstances make it difficult to deal directly with the gall-bladder, reliance can be placed on simple drainage of the abscess cavity. Seven out of eight patients so treated recovered (L. R. Fifield).

PATHOLOGICAL PERFORATION OF THE COMMON BILE-DUCT

A man of 45, whilst walking home from work, was seized with abdominal pain. With difficulty he managed to reach his destination, a quarter of a mile distant, unaided. Twenty-two hours later he was brought to hospital. The temperature was 97° F. (36° C.), the pulse 72, and he appeared very shocked and ill. The physical signs were typical of a perforated duodenal ulcer, and as he was a very thin man, shifting dullness could be demonstrated easily.

The abdomen was opened by a supra-umbilical midline incision. Pints of bile were found in the peritoneal cavity. Bile was also present in the lesser sac and *behind* the peritoneum, which was floated up. The gall-bladder looked normal, but on palpation many tiny calculi were felt within. The stomach and duodenum were examined, with a negative result. The cystic duct and supraduodenal portion of the common duct were examined with a seeker, but no perforation was demonstrable; indeed, these structures appeared quite normal. It was concluded that there was a perforation of some part of the hepatic or common bile-duct. Cholecystostomy and drainage of the peritoneum was performed. Throughout the operation the patient received saline infusion, and he was returned to bed in good condition. Next morning his pulse was good and he stated that he felt better. It was remarked that it was curious that he showed no signs of jaundice. Twelve hours later he collapsed and died. At the necropsy a perforation at the back of the junction of the cystic and common ducts was demonstrated.

I encountered a similar case; again I was unable to find the perforation and the case ended fatally. If the perforation can be found, it should be enlarged sufficiently to insert a T tube. When the perforation cannot be found, provided the patient is in good condition the duodenum and the head of the pancreas should be mobilized (*see* p. 332) in the endeavour to find a perforation in the retroduodenal portion of the common bile-duct. In any case choledochostomy, cholecystostomy, and peritoneal drainage should be performed.

To drain the common bile-duct with a T tube is absolutely essential; without this step the patient nearly always dies. Antibiotic therapy should be commenced at the earliest possible moment.

SPONTANEOUS PERFORATION OF THE COMMON BILE-DUCT AS A SEQUEL OF CHOLEDOCHOSTOMY

Wolfson and Levine have encountered three cases of spontaneous perforation of the common bile-duct following choledochostomy. The train of events is as follows: The T tube draining the common duct is removed at the appropriate time. The patient makes a satisfactory recovery, and returns home, but at a period varying from four days to six weeks is re-admitted because of a sudden onset of peritonitis. The abdominal cavity is reopened and found to contain a tremendous quantity of bile. Acute pancreatitis is the condition most likely to be confused with this syndrome. It is important to know that spontaneous rupture of the common bile-duct may follow choledochostomy. Armed with this knowledge, immediate laparotomy will be performed, instead of instituting expectant treatment.

SPONTANEOUS BILE PERITONITIS

Numbers of examples of bile peritonitis, i.e., free bile in the peritoneal cavity without a demonstrable perforation of the biliary tract, have been recorded, mostly in the Continental literature. Sir Zachary Cope, reporting six personal cases, concluded that the most logical explanation for this remarkable phenomenon was that an acute ulcer in some part of the biliary tree resulted in a *minute perforation, through which bile was forced by the normal muscular contractions of the gall-bladder.* The truth of this hypothesis was substantiated by a case reported by Small who, having

laparotomy was performed. There was swelling of the whole pancreas, which was considered undoubtedly inflammatory. The much enlarged gall-bladder was drained. Drainage of the bile-ducts via the gall-bladder together with intravenous dextrose-saline produced a remarkable improvement. Within forty-eight hours the dark jaundice had almost gone, and he has remained well.

There are occasions where doubt exists as to whether jaundice, particularly increasing jaundice, is due to infective hepatitis or to mechanical obstruction of the common bile-duct. In no circumstance whatsoever suggest an exploratory laparotomy to ascertain this point without first endeavouring to make the differential diagnosis by laboratory methods. In cases of infective hepatitis or other forms of hepatogenous jaundice any operation only increases already existing liver damage.

Fig. 415.—Patient with greatly enlarged, somewhat irregular liver, profound jaundice and cachexia. One of the many surprises in this branch of surgery. Recovered completely after cholecystostomy followed by cholecyst-gastrostomy.

Among a number of laboratory tests designed to assist in distinguishing obstructive from non-obstructive jaundice, the following are the most useful:—

Serum alkaline phosphatase. Normal value: 3–13 King Armstrong (K-A) units. Values below 20 favour hepatogenous jaundice; those above 35 obstructive jaundice.

Urobilinogen in the urine (normal approximately 0·5 mg. in 100 ml.) is absent in complete obstruction to the common bile-duct and in hepatogenous jaundice at its height. Calculus in the common bile-duct results, usually, in a fluctuating level.

Serum-prothrombin coagulation time is estimated on two days before and two days after the administration of vitamin K. If the initial value is low this is an indication for pre-operative vitamin-K therapy. When there is little or no response to vitamin K, extensive hepato-cellular damage is almost certain. Owing to large reserves, a satisfactory response does not exclude considerable liver damage.

Thymol turbidity test. A saturated solution of thymol buffered at pH 7·8 (3 ml.) is added to serum (0·03 ml.). A turbidity usually develops in cases of hepatitis, but results are nearly negative in biliary obstruction. Normal value 0–4 units (Maclagan).

Aspiration liver biopsy is a method of confirming the presence or absence of hepatic cirrhosis. Failure to aspirate a cylinder of liver occurs in about 5–10 per cent of cases; moreover the procedure is not without danger of internal hæmorrhage. When performed at laparotomy this danger is eliminated.

Suppurative Cholangitis is a grave complication, usually of stone impacted in the common bile-duct. With the exception that the patient is more deeply jaundiced, the symptoms are similar to those of pylephlebitis (*see* p. 349) and if suppurative cholangitis is not treated by early choledochostomy multiple abscesses of the liver occur, a state of affairs similar to that found in pylephlebitis.

No patient with obstructive jaundice should be abandoned as hopeless without exploration.

Preparation for Operation includes a diet containing a high proportion of carbohydrates and animal protein, reinforced by lipotrophic[1] amino-acids.

[1] Lipotrophic—increasing bodily fat.

The patient should receive 4-8-9 mg per day of synthetic vitamin K by intramuscular injection. Vitamins A and B are also given, because jaundiced patients are often deficient in this respect. The electrolytic balance particularly the serum-chloride, should be ascertained and restored to normal limits before the operation. Blood transfusion is often required. This régime should be followed for several days before and continued for several days after the operation. Definite improvement in the general condition is usually noted after the blood transfusion.

Test for Bleeding Time.—Apply a sphygmomanometer raising the pressure to 40 mm of mercury After one minute make a 3-mm. incision on the forearm. With the pressure maintained at 40 mm. of mercury the maximum time of bleeding in a normal individual is 4 minutes (Roscoe R. Graham).

Anæsthesia.—Patients with impaired liver function tolerate general anæsthesia badly On this account local anæsthesia is advisable and is effective for cholecystostomy and/or straightforward choledochostomy

The incision is a matter of considerable importance. The *midline* incision (p 139) has certain advantages. It is particularly satisfactory for use with local infiltration It is an avascular route, and it gives excellent access to the common bile-duct. The midline incision is as good as any and better than most, for a set operation of choledochostomy The *paramedian* is a very good incision. It is a little more difficult to infiltrate satisfactorily and when this incision is employed more time is expended in opening and closing This is the best incision to employ when the cause of the obstructive jaundice is doubtful, for it gives fair access to both the gall-bladder and the common bile-duct. The *limited transverse* incision (p 102) is excellent for cholecystostomy or cholecystjejunostomy

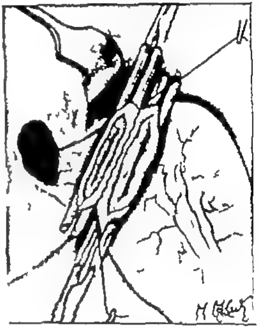


Fig 416.—Cholecystjejunostomy

The Operation.—As to the proper procedure to adopt in a given case, much judgement is required. Throughout the operation the surgeon must have his objective like a beacon light shining brightly before him. Primarily it is to relieve the obstruction secondarily and far less important, it is, if possible, to remove the cause of the obstruction.

As soon as the abdomen has been opened, examine the gall bladder

The gall-bladder is large and tense the patient is old, and jaundice is profound. Aspirate the fluid contents of the gall-bladder If green bile is recovered in considerable quantities, one knows that the obstruction will be relieved by drainage of the gall-bladder Under such circumstances rest content in performing cholecystostomy When the flow from the gall-bladder is light-coloured mucoid material, after satisfying yourself that there is no obstruction to the cystic duct, assume that this is *white bile* White bile is an accompaniment of the last stages of biliary obstruction. Drainage of the biliary passages via the gall bladder will give the patient a fighting chance

The gall-bladder is large and tense the condition of the patient is fair Palpate the pancreas. If there is a hard, irregular mass in the head, the case is probably one of carcinoma of the head of the pancreas, but not irrefutably so. *If the whole* pancreas is enlarged, it is more likely a case of chronic or subacute pancreatitis. In either case cholecystjejunostomy (*Fig* 416) can be performed. Should the patient s general condition be such that speed is essential, cholecystostomy is the better immediate procedure Cholecystjejunostomy can then be performed six weeks later but the operation is more difficult when the gall-bladder is small and contracted, as it will be after prolonged drainage.

The gall-bladder is not enlarged indeed, it is thick-walled and may be fibrotic, small or full of stones. Proceed at once to palpate the common bile-duct. A stone of fair dimensions is felt in the common bile-duct. Grasp the stone between finger and thumb (*Fig* 417) and do not let go for the stone may slip out of reach. Let the assistant retract

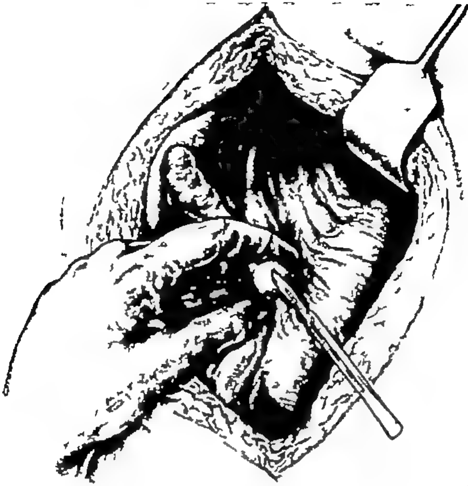


Fig. 417.—Stone impacted in the supraduodenal portion of the common bile-duct. Incision of the duct overlying the stone.

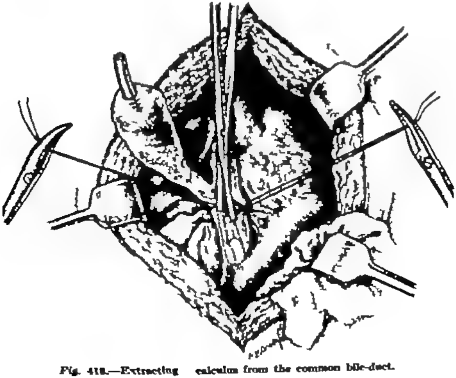


Fig. 418.—Extracting calculus from the common bile-duct.

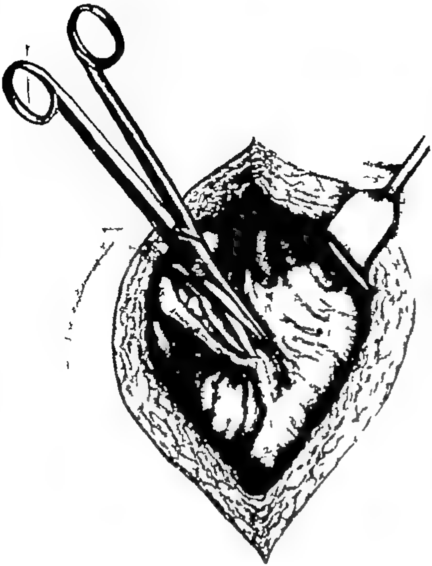


Fig. 419.—Entering the common bile-duct by way of slitting the gall-bladder and the cystic duct.

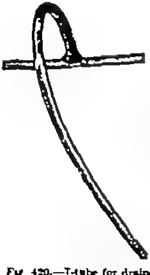


Fig. 420.—T-tube for drainage of the common bile-duct.

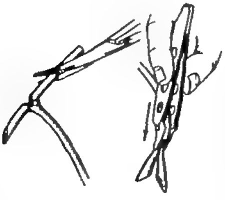


Fig. 421.—One method of modifying a T tube which facilitates introduction and withdrawal.

Fig. 422.—T tube in situ.

Fig. 423.—Maingot's T tube.

as necessary until you can see what you are holding. Incise the common duct longitudinally on to the stone, and remove it. Delicately pick up the cut edges of the common duct. Employ suction or mop up the bile which continues to flow. If circumstances permit, pass Desjardins forceps upwards and downwards within the lumen of the duct, and make sure that no other stones are within. Close the opening in the common duct about a drainage tube (*see below*).

The cause of the obstruction is doubtful. A calculus cannot be palpated in the common duct. Open the gall bladder and remove calculi, if present. Unless there is a copious free flow of bile from the gall-bladder cholecystostomy will not remedy the obstruction. Focus your attention upon the common bile-duct. When the common duct is obstructed it is enlarged, perhaps to the size of a finger, sometimes even larger. If doubt arises whether the structure under observation *is* the common bile-duct, take a hypodermic syringe, puncture the structure and aspirate. Bile is unmistakable. White bile looks like mucus. In either case, the presence of bile or mucus in the syringe is conclusive evidence that the doubtful structure is none other than that which we seek.

Being now entirely satisfied that we are dealing with an enlarged common bile-duct, choledochostomy can be performed through a longitudinal incision about ½ in. (12 mm.) long. The interior of the duct is explored deftly with Desjardins forceps (*Fig.* 418), remembering that a likely place for an elusive obstructing calculus is near the ampulla of Vater. If the patient is standing the operation poorly the only wise course is to conclude with drainage of the common duct (*see below*). Before leaving this subject it will be helpful to describe a method of entering the common bile-duct which at times proves most useful. The method is applicable only to one type of case, which is fairly common—the gall-bladder is small, the cystic duct is short and opens into the common duct without convolutions. The gall-bladder and cystic duct are slit down as shown in *Fig.* 419, until the common duct has been entered. After extracting calculi from the bile-passages, the common bile-duct and the gall-bladder are drained, the slit in the cystic duct and the neck and body of the gall-bladder being refashioned by a continuous suture.

Drainage of the Common Bile-duct.—The T-tube[1] (*Fig.* 420), if available, is very useful. Usually the transverse limbs of the T as supplied by the makers are unnecessarily long; they should be pruned, and if the tube is cut in the manner shown in *Fig.* 421 its introduction into the common duct is facilitated. Maingot's T tube (the floor of the horizontal limb is lacking) (*Fig.* 423) is more readily introduced and removed than the ordinary pattern. *Fig.* 422 will make the technique of closing the common duct about a T-tube clear.

When the T tube is not available, an ordinary drainage tube of suitable dimensions must be employed. It is valuable to have the tube armed with a stitch of fine catgut with a small round needle ready threaded on each end (*Fig.* 424). The tube is passed into the common duct in an upward direction, and it is anchored into place. The opening in the duct is closed about the tube with interrupted stitches. After a drainage tube has been inserted into the common bile-duct, omentum should be so arranged about the tube as to favour the formation of a track from the opening of the common bile-duct to the surface. It is usual to bring a tube draining the common duct out through the abdominal incision, but the first consideration should be that the tube makes a straight line to the anterior abdominal wall, and a stab incision for the exit of the tube may better suit a particular case.

After treatment.—Following the relief of the obstruction, the slow administration of dextrose-saline has a remarkably beneficial effect. By its use I have seen the skin of deeply jaundiced patients assume an almost normal tinge in forty-eight hours.

Intravenous therapy should never be employed in these cases unless it is certain that the obstruction has been relieved, as evidenced by a free flow of bile through the tube. If intravenous fluid is administered to a patient suffering from unrelieved obstructive jaundice, retained bile in the blood-stream and tissues is swept to the kidneys in quantities sufficient to interfere seriously with their function.

Gradual Decompression of the Obstructed Biliary Tree.—Often scant attention is paid to this important detail. When complete obstruction to the common bile-duct is released

[1] Latex T tubes, which are moulded in one piece, are preferable to red rubber T-tubes, which are made in two sections fused together; the latter have been known to come apart at the junction.

suddenly the intrahepatic ducts collapse. This leads to a sudden inflow of blood into the liver. The resulting intense hyperæmia is liable to cause additional damage to the liver cells. Therefore, in cases of severe jaundice, as soon as the tube has been sutured into place in either the gall-bladder or the common bile-duct, the tube should be clamped with a hæmostat. When the patient has been returned to bed the clamp is removed, the tube is connected to a saline dripper and, by means of another tube to a bedside bottle. The bile-ducts are decompressed in exactly the same way as the bladder is decompressed in

Fig. 434.—Drainage of the common bile-duct when a suitable T-tube is not available

acute retention of urine (see p. 638). The rate of flow is set at 40 drops a minute for the first 18 hours. After that time the screw clamp can be released, but the dripper is retained, as it is an excellent means of preventing retrograde infection. If the obstruction has been relieved, it is good practice to tighten the screw clamp gradually with the object of forcing bile into the duodenum, the prevention of loss of bile to the exterior being of great value.

The following case illustrates several points in the management of obstructive jaundice due to impaction of a stone in the common bile-duct :—

Fig. 435.—Mrs. M. W., showing the transverse incision and the T-tube issuing from the common bile-duct.

Mrs. M. W., aged 60, was jaundiced to an olive hue; even her conjunctivæ were green rather than yellow and her body was covered with scratch marks. A month previously she had had an attack of abdominal pain, which had passed off within 48 hours. Tenderness was elicited beneath the right costal margin where a swelling could be felt.

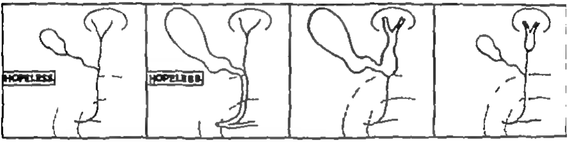
She entered hospital the next day. Vitamin K was given intramuscularly and she was encouraged to imbibe dextrose solutions. On the evening of the second day she received a blood transfusion. On the following morning ¼ gr. (16 mg.) morphine was given, and the patient was brought to the theatre, blindfolded. The abdomen was opened through a transverse incision under local anæsthesia. There were so many adhesions to the liver that the gall-bladder could neither be seen nor felt. Attention was directed towards the common bile-duct. It was soon evident that there was a stone therein, for a hard object could be felt behind the duodenum. The stone, which was about the size of a lump of sugar, was grasped between the finger and thumb and squeezed upwards. This manipulation must have been painful, but the patient co-operated by relaxing her abdomen. After two or three attempts the stone was loosened from its bed, and it could be pushed up for about an inch. By dissection immediately above the duodenum and retracting the duodenum downwards, that portion of the duct containing the stone

clay-coloured nor is the urine deeply bile-stained. The condition does not require any treatment.

Erythroblastosis foetalis et infantium (syn. icterus gravis neonatorum).—(*See* p. 60.)

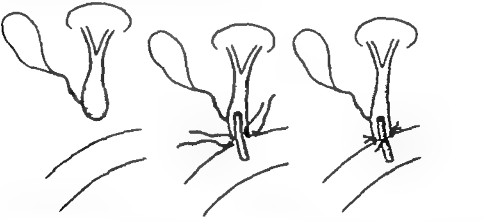
Congenital Atresia of the Bile-ducts.—Too often this condition is allowed to pass on to a fatal termination without any attempt being made to explore the abdomen and see if the condition is remediable.

When the common bile-duct or the common hepatic duct is congenitally occluded the infant becomes increasingly jaundiced and the liver enlarged (*Fig* 429). Life is usually prolonged for three or four weeks, sometimes longer but towards the end of this period the chances of a successful operation become slender The time to operate is before the fourteenth day This gives ample time for the diagnosis to be firmly established.



A B C D

Fig. 431.—Symposium of the various types of congenital obstruction to the bile-ducts, remediable and irremediable. In the remainder the ducts are blocked with epithelial debris. A, 61 per cent B, 14 per cent. C, 4 per cent. D 8 per cent.



1 2 3

Fig. 432.—The only treatment other than simple drainage to the exterior for the variety of congenital obstruction shown in (1) is to perform hepatico-duodenostomy After mobilizing the duodenum the anastomosis is made about a piece of rubber tubing (2). Fine cotton stitches complete the anastomosis (3).

Diagnosis.—The infant is usually a male. Sometimes a slight icteric tinge is present at birth, more usually jaundice appears within two or three days thereof occasionally it is delayed for up to several weeks. Unless the atresia (*Fig* 431) can be remedied the jaundice becomes deeper and deeper even tears and the saliva are yellow From birth the stools are white or clay-coloured after two weeks they may become faintly yellow the clinician must be aware of the fact that in profound jaundice a small amount of bile-pigments from the blood is excreted by the intestines. The only method of ascertaining that no bile is entering the duodenum from the liver is by an analysis of the duodenal contents withdrawn by an indwelling duodenal tube. Nutrition is fairly well maintained, especially if the baby is given feeds containing but little fat. Even with medical treatment, if the obstruction is unrelieved, death results in three to six months.

Differential Diagnosis.—The condition is distinguished from erythroblastosis fœtalis et infantium (icterus gravis neonatorum, *see* p. 60) by examination of the blood and (in congenital atresia of the bile-ducts) by the presence of white fæces.

Treatment.—

a. Medical treatment is occasionally successful when the ducts are blocked by epithelial debris. Cholagogues are given orally 250 mg of desiccated bile-salts with each feed, and intravenously 5 ml. of 20 per cent dehydrocholic acid three times a week.

b. Operative —Should the patient be anæmic pre-operative blood transfusion is given. Vitamin K is always necessary to combat the tendency of a jaundiced patient to bleed. At laparotomy (*Fig.* 430) one of the conditions shown in *Fig* 431 will be displayed. While (A) and (B), if fibrous cords, are beyond surgical aid, it is always well worth ascertaining if a tiny lumen is present in the main duct. Syringeing has sometimes proved successful in freeing

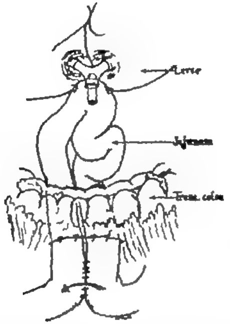


Fig 433.—Hepatico-jejunostomy (*After Petersen and Cole.*) The anastomosis need not necessarily be retrocolic.

such ducts of inspissated material. In (C) often the only method of constructing a channel for the bile to flow into the intestine is anastomosis of the common bile-duct with the duodenum (choledochoduodenostomy *Fig* 432); if however the cystic duct is indubitably patent, as is shown in *Fig* 431 (C) cholecystjejunostomy will suffice. In (D) the stump of the common hepatic duct can often be joined to the mobilized duodenum. If this is not possible, reconstruction of the common hepatic duct (hepatico-jejunostomy) should be attempted (*Fig* 433). In these anastomoses one layer of interrupted sutures is sufficient. It is necessary to place a piece of catheter through the anastomosis. In successful cases eventually it will be passed *per via naturalis* After a successful operation the enlargement of the liver abates slowly

SOME POINTS TO BEAR IN MIND IN CONNEXION WITH OBSTRUCTIVE JAUNDICE

1 There is seldom much hurry to operate upon these patients; on the other hand, they are frequently left unrelieved too long

2 Operation for the relief of obstructive jaundice should be the simplest possible but it must be adequate.

3. Cholecystectomy in addition to the relief of the obstruction is uncalled for and if attempted in the presence of jaundice the life of the patient is being endangered unnecessarily

4 The essential aim of the operation is to relieve the obstruction. A worthy objective is at the same time to remove the cause of that obstruction should it be possible.

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CHAPTER XXXI

ACUTE PANCREATITIS

In the days before the serum-amylase test for the confirmation of the diagnosis acute pancreatitis was encountered rarely and then often either at laparotomy or necropsy and unfortunately too often at both. At the present time acute pancreatitis is certainly not a very uncommon disease.

DIAGNOSIS

In its more severe forms acute pancreatitis comes on very suddenly and typically soon after a heavy meal. In these respects it simulates a perforated peptic ulcer. In 50 per cent of cases there is a history of one or more previous attacks of similar though often less severe, upper abdominal pain.

Pain is the most prominent single symptom of acute pancreatitis. The pain is agonizing and commences relatively suddenly in the mid-epigastrium, or occasionally in the right hypochondrium, and radiates to the back. When it originates in the right hypochondrium the pain suggests acute cholecystitis, but if it spreads to the left flank, this symptom points to pancreatitis, and in particular to irritation of the peritoneum of the lesser sac. Less commonly the abdominal pain becomes generalized. The severity of the pain is a rough index of the degree of pancreatic involvement. Characteristically the pain is unrelenting and unaffected by vomiting. In the endeavour to gain some measure of relief often the patient sits up in bed and leans forward.

Vomiting usually follows the pain. Bouts of retching and repeated vomiting exhaust and dehydrate the patient.

Cyanosis is a fairly common accompaniment of the most acute forms of acute pancreatitis. It is due to the profundity of the toxæmia, though perhaps anoxæmia due to the inflamed pancreas preventing full excursions of the diaphragm plays a part.

The pulse-rate is nearly always quickened from the commencement of the attack (cf PERFORATED PEPTIC ULCER).

The temperature is at first subnormal. Later if the patient rallies it rises to 99° F (37.2° C). Seldom at this stage is it higher.

Shock. In the past much emphasis has been placed on the dramatic development of shock. Some degree of shock is found in 28 per cent of cases. In very severe cases it is pronounced. When the shock had passed off it was found that in a series of patients with acute pancreatitis the blood-pressure, both systolic and diastolic, was significantly higher than in a comparable series of patients with perforated peptic ulcer (L. Heinz).

Rigidity in ultra-severe cases is absent, because the patient is collapsed. However considerable rigidity is to be expected when the initial shock has passed off, but it is not board like.

Tenderness is conspicuous in the epigastrium, and may be present in the loins, particularly the left.

Ileus is not present in the early stages. After twelve hours peristalsis diminishes and, unless it is prevented by gastro-intestinal aspiration, abdominal distension supervenes.

Leucocytosis is present (early in the attack) in less than half the cases.

Glycosuria is found in about 7 per cent of cases. It is of little diagnostic significance unless it is known that the glycosuria was not present previously. Glycosuria due to acute pancreatitis adds considerably to the gravity of the situation, for it indicates gross pancreatic destruction.

Later Manifestations of Acute Pancreatitis.—

A tender mass in the epigastrium due to entrapped fluid in the lesser sac, can often be felt on or about the fourth to the sixth day. This is of great importance from the standpoint of treatment.

Faint jaundice is discernible in 15 per cent of cases at some time during the attack, usually not until the seventh or eighth day. It is probably obstructive and due to œdema of the head of the pancreas.

Discoloration of the skin is a most exceptional manifestation, seen only in severe cases of several days standing Grey Turner described it in the loins, and likened it in appearance to that of late extravasation of urine Other observers have described similar discoloration around the umbilicus. The cause of the phenomenon is the action upon the subcutaneous fat of pancreatic ferments that have escaped from the retroperitoneal tissues, in the first instance directly and in the second instance via the round ligament of the liver

BIOCHEMICAL CONFIRMATORY TESTS

The Serum-amylase Estimation is one of the pillars upon which rests the modern concrete diagnosis of acute pancreatitis. Without this test exploratory laparotomy is often necessary and in its wake a greatly increased mortality The normal value is 80-180 Somogyi units 200 units is pathological. In acute pancreatitis the serum-amylase level often rises to 1000 units or more (in a few cases it reaches 3000 units) the highest level being attained in less than one hour after the onset of symptoms. Consecutive specimens of blood show a fairly progressive decline, so that the normal level is frequently re-established within 24–48 hours.

Seeing that during laboratory working hours the result can be available within an hour after the blood has been taken for the test, the determination of the serum-amylase can usually be employed as an emergency procedure One can make a diagnosis of acute pancreatitis with assurance in a patient with severe abdominal pain and a serum-amylase of over 1500 units. In the presence of abdominal pain and a serum-amylase between 500 and 1500 units the diagnosis of acute pancreatitis can still be made if other causes are eliminated. The facts being what they are, good practice requires that any patient with severe abdominal pain should have a serum-amylase estimation performed, and preferably repeated. The reliability of this test depends, to a large extent, on the time during the clinical course of the disease that the specimen is obtained.

Under what Circumstances, and for what Reasons, can the Serum-amylase Level be raised in a Patient with a Normal Pancreas? Apart from the presence of obvious parotitis, several conditions are associated with a raised serum-amylase level —

1 *Perforated peptic ulcer* due to the escape of pancreatic juice and absorption of its ferments. It must be emphasized that a raised serum-amylase level in perforated peptic ulcer is exceptional.

2. *Intestinal strangulation* Again the phenomenon of a raised serum-amylase level is unusual. The reason for it is obscure. This is the most difficult and dangerous condition with which to confuse acute pancreatitis.

3. *The injection of an opiate* by evoking spasm of Oddi's sphincter will of itself induce an increased, sometimes pronounced, level in the serum-amylase (H Wapshaw).

4. *Renal failure* A probably less frequently encountered factor is the possibility that a serum-amylase elevation is due to retention of the enzymes because of transient anuria and/or renal failure. In oliguria and anuria the serum-amylase level often reaches 1000 units.

5 *A mistake in technique of the determination* It takes only a tiny contamination with saliva to give a falsely high amylase value.

In view of these possible sources of error it is wise to repeat the test, especially until the effects of an opiate have subsided, before drawing a definite diagnostic conclusion. It should be noted that increase of serum-amylase from extrapancreatic causes seldom reaches the high levels often found in early acute pancreatitis.

Under what Circumstances can a Patient suffering from Acute Pancreatitis have a Normal,[1] or a Very Slightly Raised, Amylase Level?

1 When there is such extensive damage to the acinar cells of the pancreas that they are rendered incapable of elaborating the enzyme.

2. Idiopathically the anomaly has been attributed to lack of obstruction to the pancreatic ducts, which seems an important factor in the production of a positive test.

3. After one to four days following the attack.

Summarizing: In making a diagnosis of acute pancreatitis all facts must be taken into consideration. One must guard against the tendency to rely solely on a serum-amylase reading given over the telephone or entered on a slip of paper

[1] A normal serum-amylase level in acute pancreatitis is usually a bad prognostic sign (Professor Francis D Moore).

The Diastatic Index of the Urine is normal[1] during the early hours of the attack. After twelve to twenty four hours it often rises to 100 units or more. Sometimes it is as high as 500 or rarely 1000 units. It remains elevated after the serum-amylase has returned to normal; after that it, too, declines, usually to reach normality between the third and the fifth days.

Serum-lipase Estimation cannot be used for an urgent diagnosis, since the result does not become available for twenty four hours after the blood has been received by the laboratory. However, the serum-lipase remains elevated for a longer time than does the serum-amylase. Hence in a patient admitted late in the course of the attack, the nature of the condition can sometimes be determined by an elevated serum-lipase, though the serum-amylase has returned to normal levels.

Antithrombin Titre.—A remarkable and consistent rise in the antithrombin level of the blood is present in acute pancreatitis. In 50 of 55 cases a strongly positive result was obtained, and persisted for as long as five days after the onset of symptoms. No elevation was observed in a control group of 150 patients (I. Innerfield). The test is easy to perform, the result can be obtained within 20 minutes, and there are but few negative readings in acute pancreatitis. In many respects this laboratory test has an advantage over the serum-amylase estimation.

Serum-calcium.—Owing to free fatty acids combining with serum-calcium to form soaps in the areas of fat necrosis, the amount of calcium in the blood is reduced. This reduction is not appreciable until about forty-eight hours after the commencement of the attack, and becomes most apparent between the fourth and tenth days. Levels below 7 mg. per cent have sometimes been noted, but this usually reflects neglect in detailed diagnosis, and in the administration of calcium salts. Tetany rarely occurs in the presence of a low blood calcium in acute pancreatitis. It has been suggested that the stimulating effects on the neuromuscular system of a low calcium level is counteracted by the inhibiting effect of a concomitant lowered potassium level. The serum-calcium is a diagnostic help when the patient is first seen late in the disease, and in those rare, ultra-acute cases where the serum-amylase is normal, or only slightly raised.

Plasma-potassium.—A low plasma-potassium sometimes occurs, although less frequently. The use of gastric suction and a low potassium intake both contribute to the fall in potassium (H. A. Edmondson).

RADIOLOGY

In the early hours of the attack a plain film of the abdomen often shows excessive gas in the stomach and the first part of the duodenum (*Fig.* 434). In many cases a radiolucent area can be seen in the second, and sometimes the third, parts of the duodenum.

Fig. 434.—Acute pancreatitis. Radiograph two hours after onset, showing gas in the duodenum and a little in the stomach. (*S. Ollivier "Radio-Diagnostic des Occlusions Intestinales Aiguës" Paris.*)

Fig. 435.—Acute pancreatitis. Isolated loop of distended jejunum seen in plain X-ray film.

Commonly the colon is shown to be filled with gas. In the event of the stomach and the colon being visualized by the presence of gas within them, in acute pancreatitis the stomach and transverse colon are separated by an opaque zone corresponding to the pancreas, whereas in peritonitis the colon and stomach, although frequently distended, remain in contact. Later in the course of an attack of acute pancreatitis there is a sentinel loop of distended jejunum (*Fig.* 435) visible on the film in 50 per cent of cases.

[1] Normal = in a 24-hour collection up to 33 units; in a casual specimen up to 50 units.

The left side of the diaphragm is often elevated and a slight pleural effusion at the left base though not necessarily pathognomonic, aids in the diagnosis.

DIFFERENTIAL DIAGNOSIS

Difficulties in diagnosis arise because acute pancreatitis can closely imitate other abdominal and thoracic emergencies and, as has been shown, entire reliance cannot be placed in a moderately high serum-amylase test or on radiology

1 **Acute Cholecystitis.**—The differential diagnosis between acute cholecystitis and acute pancreatitis is often very difficult; indeed, in 20 per cent of cases of acute pancreatitis the patient is suffering from acute cholecystitis in addition to acute pancreatitis. When it is possible, the differential diagnosis between these two conditions is highly desirable but failure to make it does not endanger life the delayed treatment of each is unsurpassed.

2. **Perforated Peptic Ulcer**—The rigidity of acute pancreatitis is seldom board-like. Moreover in perforated peptic ulcer the plain X ray film often shows air beneath the diaphragm In the presence of an only moderately raised serum-amylase test, if diagnostic aspiration is not conclusive an exploratory incision under local anæsthesia is the best course.

3. **High Intestinal Obstruction with or without Strangulation** is a most onerous differential diagnosis, for the penalty of withholding early operation in the case of strangulated intestine is certain death. As has been described, a moderate rise in the serum-amylase level does not rule out intestinal strangulation. In both conditions the abdomen may be distended and in both conditions radiology can show gas-filled jejunum. The presence of colicky pains that come and go and the presence of turbulent bowel-sounds, overwhelmingly favour the diagnosis of intestinal obstruction. The bathing of an upper loop of jejunum in the enzyme-laden peritoneal exudate of acute pancreatitis can result in local paralytic ileus with symptoms and radiological signs identical with those of high intestinal obstruction. The absence of an obvious cause for the obstruction, with tenderness in the flanks, should make one suspicious of acute pancreatitis. In such cases, proceed as in (2).

4. **Diffusing Peritonitis** (perforated appendicitis perforated diverticulitis etc.)—Here the serum-amylase and prothrombin tests are invaluable.

5. **A Coronary Thrombosis.**—In the more severe type of acute pancreatitis the sudden onset, the cyanosis, lowered blood-pressure, and rapid pulse may suggest coronary thrombosis.

6. **Diaphragmatic Pleurisy**

In a number of instances cases belonging to categories (5) and (6) have been proved by the amylase test to be examples of acute pancreatitis with the pain higher than usual.

DIAGNOSTIC ASPIRATION

If shifting dullness is present, and it is imperative to know the nature of the flui diagnostic aspiration employing a fine needle attached to a syringe is permissible (f technique see p. 302) The peritoneal effusion of acute pancreatitis is typically colour a prune-juice shade by hæmolysed blood. In very acute cases the blood-stained fluid brighter red. The amylase level of this peritoneal fluid is higher than that found in t blood-serum, and it remains higher for a longer period of time.

LIMITED EXPLORATORY LAPAROTOMY

It is again emphasized that operation should be avoided unless it is impossible to ru out some other condition requiring urgent laparotomy Such contingencies arise mo often when the surgeon has not full laboratory and radiological facilities. When neede the following method can be recommended with confidence: after premedication wi pethidine under local infiltration anæsthesia an incision 2 in. (5 cm.) long is made in th middle line two fingerbreadths above the umbilicus. If the case is one of acute pancreati prune-juice coloured or blood-stained peritoneal fluid is observed, and tell tale areas fat necroses (*Fig* 430) will be present. In order to find fat necroses occasionally it necessary to open the lesser sac When the diagnosis of acute pancreatitis is substantiate after aspirating as much of the peritoneal exudate as possible (a sample can be sent for

serum-amylase test) the incision is closed with through-and through sutures of stainless-steel wire. No drainage is advised at this stage When some other intra-abdominal catastrophe is revealed the patient must be anæsthetized more fully according to circumstances, and the incision extended as necessary

Fig 436.—Fat necroses.

DELAYED TREATMENT

The success of the delayed treatment of acute pancreatitis depends upon the care bestowed upon its application. It also demands repeated appraisal of the patient's clinical and biochemical states. Without question this treatment offers the patient the best chance of survival. The patient is nursed mainly in the sitting position, which he finds comfortable and in many respects the treatment is similar to the Ochsner Sherren treatment of acute appendicitis (*see* p 232).

Transnasal Gastric Aspiration should be started as soon as possible. In addition to the comfort from the relief of vomiting and retching that it brings it helps to alleviate pain in no uncertain measure. Furthermore, aspiration of gastric juice as soon as it is secreted inhibits the normal hormonal stimulation of the pancreas thus physiological rest is afforded to the pancreas as well as to the stomach. It is a sound practice to punctuate continuous gastric suction with brief periods of non-suction, during which antacids are instilled into the stomach, thereby still further depressing hormonic stimulation of the pancreas.

The Relief of Pain.—Morphine, and other opiates, induce spasm of the duodenal papilla, thus increasing the pain. They should, therefore be eschewed rigorously

Pethidine (Demerol) 2 ml. (100 mg) intravenously should be the standard analgesic for acute pancreatitis. If necessary this dose can be repeated in from 1 to 4 hours.

Intravenous Procaine : In cases of exceptionally severe pain 0·3 G procaine in 500 ml of saline solution can be administered by the drip method twice daily The action is similar to that of paravertebral anæsthesia without the latter's unpleasant injection, possible fall of blood-pressure and short lived effect. Intravenous procaine relieves pain by continued local anæsthetic vasodilating and smooth muscle-relaxing effects.

Everything by mouth is withheld for at least four days.

Intravenous Fluid Therapy.—Usually *intravenous drip dextrose-saline* suffices, and is commenced early and continued for at least four days. In no other intra-abdominal catastrophe is the replacement of lost water and electrolytes more needed than in acute pancreatitis. A daily Fantus test or flame photometric urinary chloride estimation is imperative to guard against hypochloræmia. In these cases it is especially important

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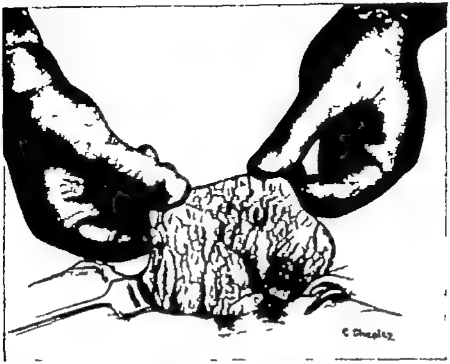

Fig. 186.—Fat necroses.

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not to overload the circulation. The administration of *whole blood and or plasma* is necessary in the treatment of severe cases, in order to combat diminution of blood volume due to loss into the peritoneal cavity of fluids rich in proteins. In severe cases the associated circulatory hypotension can often be rectified by infusion of plasma which, in addition to combating shock, is alleged to contain sufficient antitryptic activity to neutralize some of the released trypsin. In severe cases with hypotension the intravenous administration of noradrenaline (see p. 77) has proved valuable.

If prolonged gastric aspiration is required, the use of protein hydrolysate intravenously helps to spare body proteins.

Antibiotic Therapy to combat intraperitoneal and retroperitoneal infection. Aureomycin (or terramycin) is the drug of choice because it is concentrated in the bile. On account of the accompanying ileus, the antibiotic must be administered parenterally.

Calcium Therapy.—In ultra-acute cases, because of extensive fat necroses and concomitant hypocalcæmia, calcium gluconate 10 ml. of a 10 per cent solution should be given intravenously and repeated once in 48 hours, if deemed necessary.

Oxygen Therapy does not appear to remedy the cyanosis as quickly as would be expected from experience in other conditions. Nevertheless efficient oxygen therapy should be given as long as the patient exhibits cyanosis.

Hydrocortisone Therapy.—In a number of instances where it has been used, hydrocortisone has quickly brought about a remarkable change for the better in patients with ultra-acute hæmorrhagic pancreatitis who seemed likely to die. The dose is 20–50 mg. intramuscularly followed by prednisone[1] 25 mg. daily in divided doses by mouth for 5 days, after which the dose is diminished slowly. This form of therapy should be used only in desperate cases.

The Care of the Mouth.—Post-operative parotitis is a rather frequent complication; consequently the nursing staff should be especially vigilant in the disinfection of the patient's mouth.

Pancreatic Asthenia, characterized by great muscular weakness and other signs identical with hypopotassæmia (which is, no doubt, the cause) sometimes develops about the third to the fifth day. If the diagnosis of hypopotassæmia is confirmed by a lowered serum potassium level or by electro-cardiography, the administration of potassium (see p. 35) is essential.

As a rule, patients suffering from acute pancreatitis respond to conservative treatment, and within 48 hours there is gradual and steady improvement. Nothing is allowed by mouth for at least four days, and after that time it depends upon whether or not the patient has paralytic ileus. Those patients who become progressively worse fall into the category of acute hæmorrhagic or suppurative pancreatitis.

Summarizing. It is of paramount importance to search for, and correct, dehydration, electrolytic imbalance, hypotension, and insulin deficiency. Special attention must be given to calcium and potassium deficiencies of the circulation.

ANCILLARY METHODS OF TREATMENT

Intravenous Drip Infusion of Serum-albumin.—There is agreement that extensive necrosis and hæmorrhage observed in the pancreas result from the action of pancreatic enzymes liberated into its tissues. Serum albumin has an antitryptic factor. With a view to giving the freed enzymes a protein on which to expend their activity, Kenwell and Wells treated 11 consecutive patients suffering from acute pancreatitis with salt free serum albumin, the amount given being 300–500 ml. (by slow drip) daily for three to five days. In all patients the course of the disease was influenced favourably by the albumin, and no untoward reactions occurred. The temperature and leucocyte count returned to normal rapidly, and the general condition of the patient improved. When these results were compared with 19 similar cases not given albumin, it was appreciated that the beneficial effect of this treatment is striking, and may indeed be life-saving.

Ganglion-blocking Drugs, which depress pancreatic secretion, are now widely prescribed. When the pain is severe it is best relieved by giving propantheline bromide (pro-banthine)[2] 30 to 45 mg. six hourly via the indwelling gastric tube, or 15 mg. intramuscularly. If required, the drug, which reduces pancreatic secretion and lowers the concentration of enzymes in the juice, can be continued for several days.

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[1] Roussel Laboratories Ltd., 84 Harrow Road, London, N.W. 10.
[2] Pro-Banthine (G. D. Searle & Co. Ltd., 83, Crawford Street, London, W.1).

TREATMENT OF A COLLECTION OF (SEMIPURULENT) FLUID IN THE LESSER SAC

A sharp watch must be kept for the development of a tender mass in the epigastrium, which not infrequently can be felt about the fourth to the sixth day of the disease. It is due to the foramen of Winslow becoming sealed by inflammatory exudate. The entrapped fluid distends the lesser sac to such an extent that a tender mass can be felt in the epigastrium. It is sometimes accompanied by a hectic temperature and a daily leucocyte count is advisable.

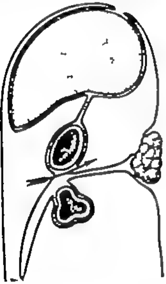

Fig 437.—Route for draining the lesser sac.

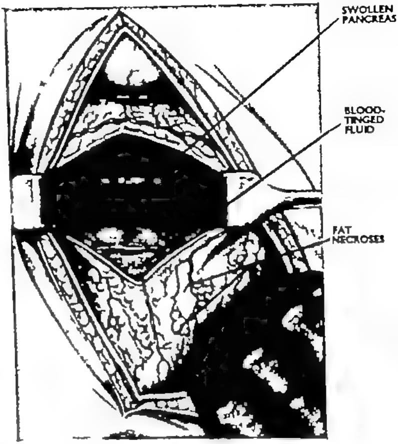

Fig 438.—The lesser sac has been opened between the stomach and the colon.

Fig 439.—Drainage of the lesser sac was performed in this very severe case of acute pancreatitis.

The sooner this semipurulent collection of fluid is drained the better. Local anaesthesia is strongly advised, and nothing more than opening (*Figs*. 437, 438) and draining the lesser sac through the short midline incision described already is required (*Fig*. 439).

Post-operative Treatment.—Escaping pancreatic juices tend to digest the abdominal wall and the sutures contained therein. It is advisable to forestall the possibility of a burst abdomen by applying an abdominal corset forty-eight hours after the operation. Digestion of the skin around the wound can be prevented to a large extent by smearing it with paraffin ointment containing 0·2 per cent of hydrochloric acid, which renders the ferments impotent, or aluminium paste can be used. Sump drainage is an excellent additional prophylactic measure.

In the early stages feeds should be pancreatised, and fats should be withheld as far as possible.

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Antibiotic Therapy to combat intraperitoneal and retroperitoneal infection. Aureomycin (or terramycin) is the drug of choice because it is concentrated in the bile. On account of the accompanying ileus, the antibiotic must be administered parenterally

Calcium Therapy.—In ultra-acute cases, because of extensive fat necroses and concomitant hypocalcæmia, calcium gluconate 10 ml of a 10 per cent solution should be given *intravenously* and repeated once in 48 hours, if deemed necessary

Oxygen Therapy does not appear to remedy the cyanosis as quickly as would be expected from experience in other conditions. Nevertheless efficient oxygen therapy should be given as long as the patient exhibits cyanosis.

Hydrocortisone Therapy.—In a number of instances where it has been used, hydrocortisone has quickly brought about a remarkable change for the better in patients with ultra-acute hæmorrhagic pancreatitis who seemed likely to die . The dose is 20–30 mg intramuscularly followed by prednisone[1] 25 mg daily in divided doses by mouth for 5 days, after which the dose is diminished slowly . This form of therapy should be used only in desperate cases.

The Care of the Mouth.—Post-operative parotitis is a rather frequent complication; consequently the nursing staff should be especially vigilant in the disinfection of the patient's mouth.

Pancreatic Asthenia, characterized by great muscular weakness and other signs identical with hypopotassæmia (which is, no doubt, the cause) sometimes develops about the third to the fifth day If the diagnosis of hypopotassæmia is confirmed by a lowered serum potassium level or by electro-cardiography the administration of potassium (see p. 85) is essential.

As a rule, patients suffering from acute pancreatitis respond to conservative treatment and within 48 hours there is gradual and steady improvement. Nothing is allowed by mouth for at least four days, and after that time it depends upon whether or not the patient has paralytic ileus. Those patients who become progressively worse fall into the category of acute hæmorrhagic or suppurative pancreatitis.

Summarizing It is of paramount importance to search for and correct, dehydration, electrolytic imbalance hypotension and insulin deficiency Special attention must be given to calcium and potassium deficiencies of the circulation.

ANCILLARY METHODS OF TREATMENT

Intravenous Drip Infusion of Serum-albumin.—There is agreement that extensive necrosis and hemorrhage observed in the pancreas result from the action of pancreatic enzymes liberated into its tissues. Serum albumin has an antitryptic factor With a view to giving the freed enzymes a protein on which to expend their activity Kenwell and Wells treated 11 consecutive patients suffering from acute pancreatitis with salt free serum albumin the amount given being 300–500 ml. (by slow drip) daily for three to five days. In all patients the course of the disease was influenced favourably by the albumin, and no untoward reactions occurred. The temperature and leucocyte count returned to normal rapidly and the general condition of the patient improved. When these results were compared with 19 similar cases not given albumin, it was appreciated that the beneficial effect of this treatment is striking and may indeed be life-saving

Ganglion blocking Drugs, which depress pancreatic secretion, are now widely prescribed. When the pain is severe it is best relieved by giving propantheline bromide (pro-banthine)[2] 30 to 45 mg six hourly via the indwelling gastric tube or 15 mg intramuscularly If required the drug which reduces pancreatic secretion and lowers the concentration of enzymes in the juice can be continued for several days.

[1] Roussel Laboratories Ltd., 847 Harrow Road, London, N.W. 10.
[2] Pro-Banthine (G. D Searle & Co. Ltd., 83 Crawford Street London, W 1).

TREATMENT OF A COLLECTION OF (SEMIPURULENT) FLUID IN THE LESSER SAC

A sharp watch must be kept for the development of a tender mass in the epigastrium, which not infrequently can be felt about the fourth to the sixth day of the disease It is due to the foramen of Winslow becoming sealed by inflammatory exudate The entrapped fluid distends the lesser sac to such an extent that a tender mass can be felt in the epigastrium. It is sometimes accompanied by a hectic temperature and a daily leucocyte count is advisable

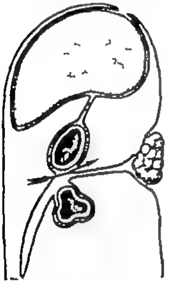

Fig 437 —Route for draining the lesser sac

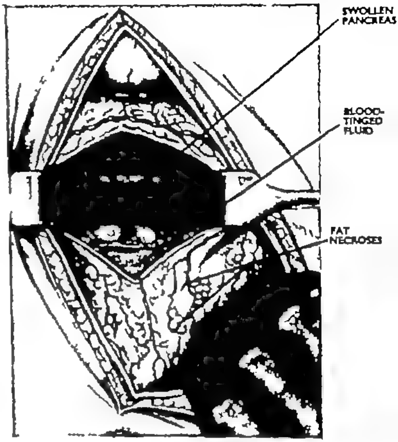

Fig 438 —The lesser sac has been opened between the stomach and the colon.

Fig 439 —Drainage of the lesser sac was performed in this very severe case of acute pancreatitis.

The sooner this semipurulent collection of fluid is drained, the better Local anaesthesia is strongly advised and nothing more than opening (*Figs* 437 438) and draining the lesser sac through the short midline incision described already is required (*Fig* 439)

Post-operative Treatment.—Escaping pancreatic juices tend to digest the abdominal wall and the sutures contained therein. It is advisable to forestall the possibility of a burst abdomen by applying an abdominal corset forty-eight hours after the operation. Digestion of the skin around the wound can be prevented to a large extent by smearing it with paraffin ointment containing 0·2 per cent of hydrochloric acid, which renders the ferments impotent, or aluminium paste can be used. Sump drainage is an excellent additional prophylactic measure.

In the early stages feeds should be pancreatized and fats should be withheld as far as possible

PERIPANCREATIC ABSCESS BURROWING POSTERIORLY

During the conservative management of acute pancreatitis it must not be forgotten to make frequent examinations of the lumbar region for tenderness. In the rare event of persistent tenderness and the development of overlying cutaneous oedema of the left loin—signs that indicate that a peripancreatic abscess is burrowing posteriorly—the abscess should be drained through a vertical incision beneath the 12th rib. By burrowing with the finger towards the head of the pancreas, pus is likely to gush forth with minimum disturbance to the gravely ill patient.

SEVERE HÆMORRHAGE AS A CAUSE OF DEATH

The hæmorrhage is characteristically preceded by the development of pyrexia, usually fourteen to twenty-one days after the onset of the attack. Since 1946 hæmorrhage has become one of the chief causes of death in cases of acute pancreatitis. It is believed that antibiotics prevent early death from infection, and that hæmorrhage is the result of necrosis of a large peripancreatic blood vessel, e.g. the splenic vein. The hæmorrhage occurs into the peritoneum and/or through a drainage tube. More rarely it has occurred per rectum and through the mouth. In most of the reported cases the patient has not rallied with blood transfusion. In a few the abdomen has been opened or reopened, but the bleeding vessel could not be identified and packing has been inserted without success. It is highly important to drain a collection of fluid in the lesser sac in order to prevent this source of erosive fluid causing dissolution of the walls of a large blood vessel (C. K. Kirby et al.).

INVESTIGATION OF THE BILIARY TRACT

Two weeks after an attack of acute pancreatitis has subsided, cholecystography with visualization of the bile-ducts is undertaken. As a result of this investigation about 70 per cent of patients will prove to be suffering from coexistent biliary tract disease.

TREATMENT AFTER ACUTE PANCREATITIS HAS SUBSIDED

Medical Treatment.—Operation on the biliary tract is hardly to be considered in cases where there are no clinical symptoms of cholecystitis, and above all when there is no radiological evidence of cholecystitis or obstruction to the duodenal papilla. Cholecystectomy in such cases (which is too often performed) only brings discredit on an extraordinarily good operation. Medical supervision should include a strict dietetic régime and abstinence from alcohol, in the endeavour to prevent a relapse.

Interim Operation.—In those cases where it is indicated, laparotomy can be undertaken safely within two weeks of subsidence of all symptoms. On opening the abdomen it is likely that some evidence of fat necrosis will still be present, and the pancreas will feel enlarged. Attention is directed to the gall-bladder. The course to be followed will vary according to whether the gall bladder is thin-walled and comparatively normal, or thickened and fibrotic. If the elasticity of the wall of the gall bladder is not appreciably impaired, undoubtedly the operation of choice for an obese, poor risk patient is to proceed at once to perform cholecyst-jejunostomy, with the objective of by-passing the bile. In other circumstances cholangiography is helpful in determining whether obstruction to the ampulla of Vater is present. In any case, when the gall-bladder is small, fibrotic and contains calculi, cholecystectomy is indicated. Nevertheless, unless the patient is fit enough to undergo sphincterotomy[1] in addition, it is unlikely that cholecystectomy per se will prevent further attacks of acute pancreatitis, or stay the progress to chronic pancreatitis. In spite of a well-chosen and well-executed interim operation, relapses occur in no less than one-third of these patients.

ACUTE POST-OPERATIVE PANCREATITIS

Acute pancreatitis occasionally follows gastric resection or partial pancreatectomy. It is manifested by severe epigastric pain passing to the back, restlessness, followed by shock in varying degrees, within a few days of the operation. Jaundice may supervene. The diagnosis is made by the serum-amylase test.

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[1] A description of this operation is beyond the scope of this work.

In 14 cases where the onset of acute pancreatitis followed an upper abdominal operation, the pancreas had been manipulated or incised in each instance. The operations were :—

Subtotal gastrectomy	6
Subtotal pancreatectomy	5
Biopsy of pancreas	2
Right colectomy with partial pancreatectomy	1

All the patients had relatively severe pancreatitis. The mortality is much higher than that of idiopathic acute pancreatitis. Seven of the patients died of hæmorrhage, and one of infection (C. E. Kirby et al.)

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CHAPTER XXXII

OTHER EMERGENCY CONDITIONS IN THE UPPER ABDOMEN

SUBDIAPHRAGMATIC ABSCESS

Signs of pus somewhere, signs of pus nowhere else, signs of pus there. (Harold Barnard.)

SUBDIAPHRAGMATIC suppuration is sufficiently common to make it imperative for the emergency surgeon to study the subject closely and endeavour to master it. At the outset he must face the fact that, if unreported cases and those which die without the abscess being drained are taken into the assessment, subdiaphragmatic abscess is linked with the formidable mortality of about 40 per cent. The chief obstacle to overcome is too late the diagnosis, always difficult, so often becomes confused because of the concomitant signs in the base of a lung.

Subphrenitis may give rise to all the constitutional and local symptoms and signs produced by a subdiaphragmatic abscess except, of course, those of a space-occupying lesion.

An important consideration, and one which is not generally appreciated, is that in a high percentage of cases subdiaphragmatic *infection* resolves, consequently many examples of infection of the space pass through our hands, perhaps suspected, but never diagnosed concretely. Alton Ochsner places the number of cases falling into this category as high as 70 per cent. It is only when suppuration occurs that failure to diagnose the condition spells disaster, for unless the abscess bursts into the bronchial tree the patient is doomed.

Antibiotic therapy will doubtless be commenced at an early stage of the subphrenitis. It should be remembered that the infection is often mixed; it is therefore advisable to administer streptomycin in addition to penicillin, or aureomycin can be substituted. If the constitutional symptoms subside and do not recur, the condition is one of subphrenitis, and antibiotic therapy should be continued until one is certain that resolution is complete. On the other hand, antibiotic therapy will have but little effect on a formed abscess. It should, however, be given pre-operatively and post-operatively. In the latter case, when the sensitivity of the organisms present to antibiotics has been ascertained, the most suitable antibiotic can be given with precision.

A Space-occupying Lesion is present.—To most surgeons subdiaphragmatic abscess means right subdiaphragmatic abscess. Consequently subdiaphragmatic abscesses on the left side, which should be expected once in every four or five cases, are missed or delayed unduly even more than those on the right side. In a series reported from the Mayo Clinic by Berners et al. the location of the abscess was as follows:—

On the right side	114
On the left side	30
Bilateral	4
	134 cases

The average duration of the symptoms before the subdiaphragmatic abscess was diagnosed and drained was 130 days.

THE SEVEN SUBDIAPHRAGMATIC SPACES

The subdiaphragmatic region is bounded above by the diaphragm and below by the transverse colon and the transverse mesocolon. It includes five intraperitoneal and two extraperitoneal spaces. Of the intraperitoneal spaces, two are situated on the right and three on the left side.

The right suprahepatic space lies between the right dome of the diaphragm and the anterior superior and right surfaces of the right lobe of the liver (*Fig.* 440 A).

The right infrahepatic space is better known as Rutherford Morison's pouch (*Fig.* 440 B).

The left suprahepatic space is situated between the left lobe of the liver and the left dome of the diaphragm, and it is separated from its fellow on the right side by the falciform ligament.

The left infrahepatic space is divided by the stomach into (*a*) an anterior and (*b*) a posterior space (*Fig* 441) It should be noted that the left postero-inferior space is the lesser sac.

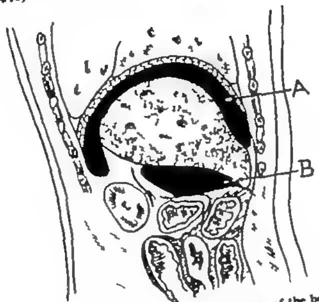

Fig 440.—Sagittal section through the right side of the body showing: (A) Right suprahepatic space (B) Right infrahepatic space

The right extraperitoneal space is comparatively large It is situated between the e area of the liver (which is situated on the back of the right lobe) and the diaphragm.

The left extraperitoneal space occupies the cellular tissue between the left kidney and suprarenal gland posteriorly and the pancreas anteriorly (*Fig* 441)

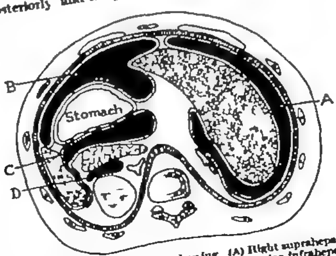

Fig 441 —Cross-section of the body showing (A) Right suprahepatic space; (B) Left anterior infrahepatic space; (C) Left posterior infrahepatic space (D) Left extraperitoneal space (*Modified from Berners et al.*)

An abscess in either the right or the left *suprahepatic space* seldom occupies the whole space It is limited by adhesions to a portion of the space Such an abscess is often situated mainly anteriorly or mainly posteriorly—more often mainly anteriorly Likewise an abscess of the *right infrahepatic space* may manifest itself in front or behind. An abscess of the *left anterior infrahepatic space* is limited to the left hypochondrium, while an abscess of the *left posterior infrahepatic space* (lesser sac), like a pseudopancreatic cyst, presents in the middle line.

Aetiology.—Nearly all subdiaphragmatic abscesses follow a known intraperitoneal lesion. The commonest causes of subdiaphragmatic abscesses are:—

1. Perforated peptic ulcer	33 per cent
2. Acute appendicitis (usually retrocæcal)	20 per cent
3. As a complication of an abdominal operation other than for the above	10 per cent

Then follows a miscellaneous collection of intra-abdominal inflammatory conditions, on the relative frequency of which it is unprofitable to linger, save to mention that post partum cases (*Fig.* 442) are not very uncommon.

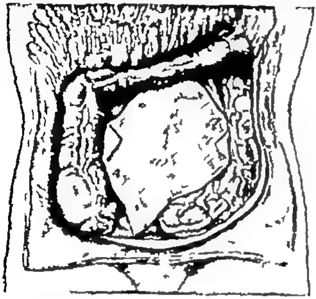

Fig. 442.—The trail of pus from the pelvis to the *left* subphrenic space. Pelvic suppuration, particularly post partum, is a frequent source.

In *cases of subdiaphragmatic* abscess following a perforated duodenal ulcer a suprahepatic abscess is *frequently an extension of a subhepatic abscess.* This suggests that if in late cases of perforated duodenal ulcer and *in perforations that are* difficult to close, Rutherford Morison's pouch was drained more often, we should be spared quite a number of subdiaphragmatic abscesses. The same is true for the Polya type of partial gastrectomy especially in cases when difficulty is experienced in closing the duodenal stump.

Regarding the third group, the operation in question is most frequently cholecystectomy, and secondly, and nearly as frequently, partial gastrectomy with leakage of the duodenal stump. These two operations account for three-quarters of all cases of subdiaphragmatic abscess attributable to an abdominal operation, but excluding those performed for (1) and (2).

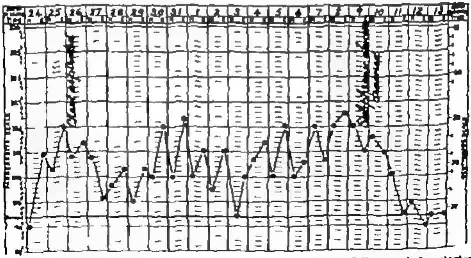

Fig. 443.—The temperature chart of A. H. B. after the third week following cholecystectomy. Note the hectic temperature and the termination of pyrexia following drainage of the subphrenic abscess.

Bacteriology.—The predominant organisms are streptococci, *Bact. coli* and staphylococci. A mixed infection is present frequently.

Diagnosis.—The majority of patients with a subdiaphragmatic abscess feel ill. In addition to pain, they complain of anorexia and nausea. The complexion is frequently muddy.

The temperature nearly always fluctuates between 100° and 102° F (37·8° and 38·9° C.) or more (*Fig* 443) In a few cases it alternates, remaining lower but rarely normal, for a few days, and then rising again. Exceptionally the patient is apyrexial In these cases the prognosis is extremely bad

Rigors are uncommon and usually occur in patients with concomitant pylephlebitis or a liver abscess.

The pulse-rate is less than 100 in a third of cases, between 100 and 120 in a third of cases, and more than 120 in a third of cases (H. R S. Harley)

The respiratory rate is usually raised and corresponds to the extent and nature of the thoracic complications.

Pain is felt on the side of the lesion, or in the middle line. It is often localized in the hypochondrium, although nearly as frequently it is experienced in the lower part of the thorax of the corresponding side. In a much smaller percentage of cases the pain is located in the lumbar region or in the neighbourhood of the 11th and 12th ribs. Referred pain to the corresponding shoulder is not infrequent, but special inquiries must be made concerning it.

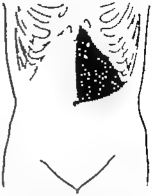

Fig 444.—Area of tenderness and fullness in left anterior infrahepatic abscess.

Swelling is present in 25 per cent of cases. It is situated very much more frequently in the right or left hypochondrium than posteriorly

Tenderness is present in 40 per cent of cases, always on the side of the lesion and more commonly anteriorly (*Fig* 444) than posteriorly

Discharge When the primary lesion is or was situated in the right upper abdomen, nearly always there is a persistent purulent discharge from the operation wound.

Downward displacement of the liver is uncommon, and in one-third of cases in which such displacement occurs it is due to a concomitant abscess of the liver

Fig 443.—Subdiaphragmatic abscess, showing elevation of the diaphragm. (*A L. d'Abreu.*)

Jaundice is most unusual in subdiaphragmatic abscess. When it is present it is nearly always due to coexisting obstruction to the common bile-duct by a calculus or to suppurative pylephlebitis.

Persistent hiccup is rare, and in this condition is of grave omen.

Examination of the blood Leucocytosis is nearly always much in evidence; secondary anæmia is common.

Thoracic symptoms and signs As emphasized already there is a high incidence of symptoms, and especially signs, in the corresponding base of the thorax. These include cough with sputum, dullness to percussion, and diminished air entry

Radiology—In spite of the fact that in about 10 per cent of cases of subdiaphragmatic abscess radiological signs are absent, in most cases X-ray examination is an invaluable method of confirming the diagnosis and of localizing the site of the abscess. Films should be taken in the postero-anterior and the lateral positions, with the patient upright. Whenever the patient is well enough, he should also be screened, if necessary in the recumbent position. The particular value of screening is that the movements of the diaphragm can be observed. Positive radiological signs are as follows —

1 Diminution or abolishment of diaphragmatic movement on the affected side.

2. Elevation of the diaphragm (*Fig* 443) also a most valuable sign, is more likely to be present on the right, than the left side

3. Increase in thickness of the diaphragm, with loss of sharp definition of its upper border

4 Radiological signs in the pleural cavity of the corresponding side by far the commonest being a pleural effusion. In addition collapse of the lung or pneumonitis may be present.

5 Gas in the abscess cavity is most illuminating but it is present in only 25 per cent of cases. The presence of gas indicates that the abscess has been in communication with the alimentary tract, a bronchus, or the exterior In rare cases gas is a product of gas-forming organisms It must also be remembered that air which gained entrance at the time of laparotomy sometimes takes 10–14 days to become absorbed. To give the patient a Seidlitz powder before the examination, and so to distend the stomach, is most helpful in distinguishing subdiaphragmatic gas from a bubble in the fundus of the stomach. Alternatively a small amount of barium emulsion and screening the patient in Trendelenburg's position can be employed.

Needling for a Subdiaphragmatic Abscess should be forbidden absolutely It may be quite justifiable to pass a needle into the pleural cavity (*see* p 708) to ascertain whether fluid is present and the nature of that fluid, but to pass the needle onwards in the endeavour to locate pus beneath the diaphragm is the quintessence of impropriety In no circumstances, whoever advises it should the surgeon weaken in his resolve to refrain from attempting to confirm the diagnosis by this expedient, for if he passes the needle through the pleural cavity and a subdiaphragmatic abscess is present, inevitably the pleural cavity will become seriously infected.

DRAINAGE OF A SUBDIAPHRAGMATIC ABSCESS

Transthoracic drainage should be avoided absolutely for the mortality of drainage by this route is nearly 2½ times as great as that of extraserous[1] drainage According to the site of maximum tenderness and the X ray appearances, one of two routes is chosen—

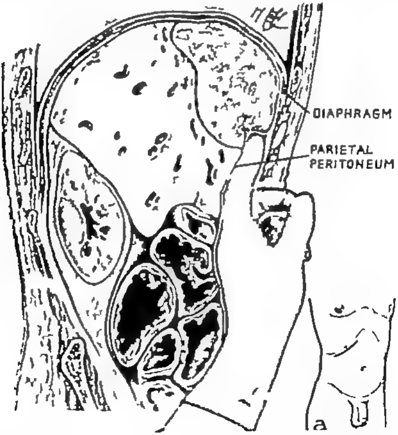

Fig. 440.—Drainage of a right suprahepatic subdiaphragmatic abscess.

[1] Extraserous The line of section must traverse neither the pleural cavity (whether the layers are adherent or not) nor an *uninvolved* portion of the peritoneal cavity

the anterior or the posterior. In both the approach is meticulously extraserous. Anaesthesia can be accomplished by a paravertebral block of the lower six thoracic nerves, combined with local infiltration. Of course endotracheal general anaesthesia makes the operation less arduous for the surgeon, but whether it is harmless to a patient who has in all probability at least some pulmonary involvement is extremely doubtful.

The Anterior Extraserous Operation

An incision is made 1 in. (2.5 cm.) below and parallel to the costal margin, from the middle of the rectus abdominis, extending laterally sufficiently to provide an opening large enough to accommodate the hand (*Fig.* 446 inset). The external oblique, the internal oblique and the transversalis muscles are divided in the line of the incision. Unless it is absolutely necessary in order to gain sufficient room, the rectus sheath is not incised, the reason being that it is advisable to avoid soiling the interior of the sheath with pus. The incision exposes the peritoneum; attention is focused on the extraperitoneal areolar tissue. In order to expose the suprahepatic space the finger burrows upwards in the extraperitoneal areolar tissue between the peritoneum and the diaphragm. With the finger, the peritoneum is peeled off the diaphragm. Especially when inflammatory oedema is present, this peeling is accomplished easily. The abscess (*Fig.* 446) is recognized by induration and is opened by forcing the finger through its wall. The left anterior infrahepatic space is opened by inserting the finger upwards and backwards between the upper border of the stomach and the under surface of the left lobe of the liver (*Fig.* 447).

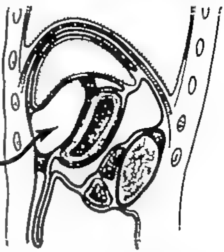

Fig. 447.—The anterior extraserous approach to an abscess of the left infrahepatic space located anteriorly. (*After H. R. S. Harley.*)

The Posterior Extraserous Operation

The patient is placed on his sound side, the sandbag or bridge elevating the lumbar region. The skin incision is made over the 12th rib, commencing 1 in. (2.5 cm.) from the middle line and extending to beyond its tip. The incision must be long enough to accommodate the hand. The 12th rib is exposed and its periosteum incised along the length of the rib and, after freeing the periosteum with suitable rougines, the sacrospinalis is retracted so as to gain access to the posterior end of the rib. The whole length of the shaft of the rib is then excised subperiosteally. The next step is to incise the bed of the 12th rib transversely at the level of the first lumbar vertebra (*Fig.* 448). If a higher level than this is chosen, the pleura will be endangered. This incision passes through the bed of the 12th rib, dividing the periosteum and the muscles attached to the rib. Deep to these the diaphragm is severed. The diaphragm at this site may be well or poorly developed. Beneath the diaphragm will be found the perinephric fat. Blunt dissection in it will reveal the posterior layer of the renal fascia, through which the perirenal fat can be seen. The

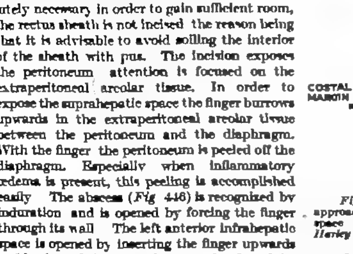

Fig. 448.—Showing the transverse incision made through the bed of the resected twelfth rib. (*After Ochsner and Graves.*)

renal fascia is not divided. By dissection with the finger the upper pole of the kidney the suprarenal gland is sought. The finger passes over the suprarenal gland, and on right side it is easy to explore the right suprahepatic and right infrahepatic (*Fig* 449 well as the right extraperitoneal space, provided the incision is large enough to accommo the hand. To explore the right infrahepatic space the finger is thrust below the r lobe of the liver

On the left side the left suprahepatic space (*Fig* 450) and the left extraperitoneal s can be examined.

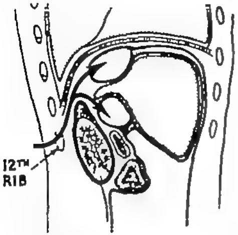

Fig 449 —The path taken by the fingers in draining a right suprahepatic and a right infrahepatic abscess by the posterior route (*After H R S Harley*)

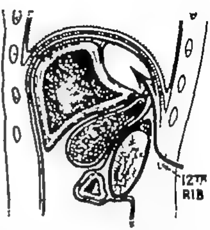

Fig. 450.—The posterior extraserous approach to a left-sided suprahepatic abscess. (*After H R S Harley.*)

A Midline Incision

This is used when tenderness and swelling are situated in the epigastrium, which is sometimes the case when a right extraperitoneal abscess tracks forwards between the layers of the falciform ligament

An abscess of the left posterior infrahepatic space (lesser sac) is the one exception where the peritoneum must be opened in order to effect drainage of the abscess. The abscess is approached by entering the lesser sac between the colon and the stomach via a midline incision.

Post-operative Treatment

This should include a nourishing diet with added vitamins. Transfusion with fresh blood is most beneficial when the patient is anæmic. Respiratory exercises to encourage full function of the diaphragm are essential.

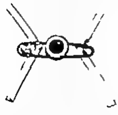

Fig 451 —Method of anchoring the tube draining a subdiaphragmatic abscess.

Management of the Drainage Tube.—The drainage tube should be a fairly large one (½ in. in diameter). Its end is bevelled, but no side holes are cut side holes render that portion of the tube beyond the holes ineffective and granulations are prone to grow into the holes (Harley). The tube should project very little above skin level, and is kept in place by a safety-pin and adhesive tape (*Fig* 451). The dressings are maintained by corsettage

In the early stages of drainage of a large abscess the tube can be connected to a water-seal bottle. When the discharge is reduced to 1 oz. (28 3 G) per day closed drainage is abandoned in favour of dressings. The drainage tube must not be shortened until it has been shown by a series of radiographs in two planes at right angles to one another taken after injecting lipiodol through a catheter inserted down the tube that the abscess cavity has become obliterated The lipiodol must not be allowed to escape This is achieved by plugging the end of the tube with gauze and keeping the patient in such a position that the medium will not run out. If any is spilled on the skin, it must be wiped away with gauze dampened with methylated ether

before the radiographs are taken. When the radiographs show that the abscess cavity has filled in and only the tube track remains, the tube is shortened tardily and finally removed

COMPLICATIONS

Complications attributable to subdiaphragmatic infection occur in about two-thirds of all cases. The most common complications are —

Pleural effusion	53 per cent of cases
Pneumonitis	30
Empyema	23 ,,
Bronchopleural fistula	11
Suppurative pericarditis	2 ,, ,,

Except in cases of pleural effusion, often more than one of these complications occurs in the same patient.

The presence of complications, more especially *suppurative complications*, has a profound bearing on the prognosis. The death-rate for patients with complications is five times that of patients without complications.

Serous Pleural Effusion requires no treatment unless it is causing mechanical respiratory embarrassment, when the fluid is withdrawn by aspiration. To ensure that the subdiaphragmatic abscess is not entered, the needle must be inserted well above the diaphragm. After drainage of a subdiaphragmatic abscess, a serous pleural effusion becomes absorbed.

The three most important causes of *intrathoracic suppuration* are rupture of the abscess through the diaphragm transpleural drainage or needling of the abscess, and penetrating thoraco-abdominal wounds. The first is by far the most common.

Empyema is more commonly first recognized after than before, drainage of a subdiaphragmatic abscess. When a subdiaphragmatic abscess and an empyema are present together each must be drained separately with if possible, an interval of 48 hours between operations.

Spontaneous Rupture of a Subdiaphragmatic Abscess into a Bronchus usually occurs via the pleural cavity In other words, the subdiaphragmatic abscess ruptures into the pleural cavity and later the resulting empyema ruptures into the bronchus. Although the patient s condition is improved by the latter happening it does not provide satisfactory drainage of the original abscess, and drainage of the subdiaphragmatic abscess by operation should be undertaken as soon as possible.

Suppurative Pericarditis, which is always secondary to an empyema, is often overlooked, with fatal results. The pus should be aspirated, and if this is not soon effective drainage of the pericardium should be carried out.

PYLEPHLEBITIS (PORTAL PYÆMIA)

Although pylephlebitis can follow suppurative disease in any part drained by the portal system, in more than 70 per cent of cases it arises as a complication of acute appendicitis, in which case the train of events is as follows as a result of direct extension of infection from the lumen of an acutely inflamed obstructed appendix, thrombophlebitis of the appendicular veins occurs. The thrombophlebitis extends to the ileocolic vein and from thence to the superior mesenteric vein. At an early stage of the spreading intravascular clotting pieces of thrombus become detached and are swept to the liver where they lodge and form abscesses. Alternatively if a gangrenous appendix occupying the splenic position lies in juxtaposition to the mesentery radicles of the superior mesenteric vein can be infected directly

The abscesses in the liver resulting from pylephlebitis are usually small and multiple (*Fig* 452); little wonder that the prognosis is bad. Nevertheless, as long as the patient has a good hold on life, we should assume that he is to be an exception. Recovery is possible in one of two ways (1) Resorption of small abscesses can occur especially with the aid of antibiotic therapy (2) Infrequently one or two large intrahepatic abscesses form, drainage of which is usually the prelude to a successful issue.

Pylephlebitis is less common than formerly; this is accounted for by the earlier diagnosis and treatment of appendicitis,[1] antibiotic therapy and the wide appreciation of the fact that prolapsed or strangulated hæmorrhoids must never be excised while they are inflamed.

[1] The incidence of pylephlebitis in acute appendicitis is 0·03 per cent.

Diagnosis.—In as far as pylephlebitis arising as a complication of appendicitis is concerned, two clinical types are encountered —

1 Rigors occur soon after the onset of an attack of appendicitis, and except for the rigors the signs and symptoms leave no doubt that the patient is suffering from acute appendicitis.

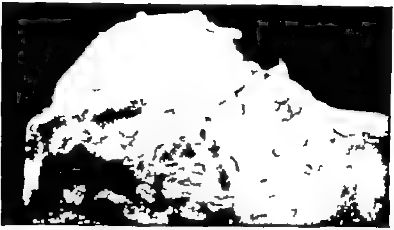

Fig 432.—Pylephlebitis. Liver honeycombed with small abscesses.

2. The symptoms and signs of appendicitis are atypical and the diagnosis is not made early as is liable to occur when the appendix is high and retrocaecal. The absence of signs in the right iliac fossa and the presence of rigors mislead the clinician as a consequence much valuable time is lost. It is worth bearing in mind that in several reported cases a plain radiograph showing one or more faecoliths in the appendix has proved to be the turning point in arriving at the correct diagnosis. It is possible though most unusual, for pylephlebitis to occur as a late complication of appendicitis, and this holds good for cases treated by appendicectomy as well as those treated by the Ochsner Sherren method.

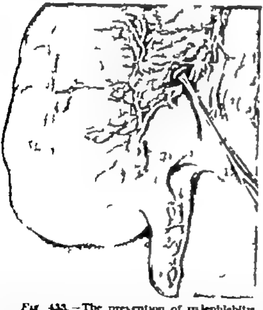

Fig 433.—The prevention of pylephlebitis. Isolating the ileocolic vein preliminary to passing the ligature

Pylephlebitis is characterized by a hectic temperature rising to 102 F (38 9 C.) or more *Recurring rigors are never absent* and in relevant cases it is this symptom that helps to distinguish the condition from a subdiaphragmatic abscess but it does not exclude it. In one-third of cases the liver becomes palpably enlarged In a somewhat higher proportion the patient is slightly jaundiced, i.e. there is an icteric tinge of the conjunctivae when observed in daylight. If tested for urobilin will be found in the urine *in every case* Diarrhœa is a usual accompaniment. Moderate ascites occurs in a few cases. In a little more than half the cases the blood culture is positive *Esch coli* hæmolytic streptococcus, *Str viridans*, and a mixed infection containing *Cl. perfringens* are the organisms most frequently cultured.

Treatment.—If a rigor occurs at the onset of an attack of acute appendicitis one should proceed as follows withdraw a sample of blood, if possible during or directly after the rigor and send it to the laboratory for culture and, if positive for sensitivity of the organisms present to antibiotics. Commence antibiotic therapy forthwith by giving 500 000 units of penicillin and 0 5 G of streptomycin, or a broad spectrum antibiotic Perform appendicectomy urgently and by clipping and cutting near the cæcal attachment remove the

mesoappendix as completely as possible If thrombophlebitis is found ligation of the thrombosed vessel well above the thrombus should be undertaken.

Ligation of the Ileocolic Vein.—The cæcum is drawn well out of the wound and the superior ileocæcal angle sought. The vein is located and traced upwards about 2 in. (5 cm.) where it will be found to be joined by other cæcal branches. Using a Watson Cheyne dissector the vein is isolated from its peritoneal covering (*Fig.* 453) and is divided between ligatures, taking care not to include the artery I have practised the measure on a number of occasions. In each instance the patient had rigors prior to the operation. All made a smooth recovery Possibly they were saved from portal pyæmia.

Antibiotic Therapy.—After operation a broad spectrum antibiotic is given and continued, unless sensitivity tests of organisms obtained from the blood-stream indicate otherwise. Antibiotic therapy should be maintained for at least 10 days after the temperature has been normal

A man of 82 developed pylephlebitis as a complication of atypical appendicitis. After appendicectomy and drainage of the associated abscess and ligation of the ileocolic vein had been performed, the patient received 1 G of aureomycin four-hourly by mouth for 14 days. Recovery followed. (*Manson and Maynell.*)

Blood Transfusion is given when, as is often the case, the hæmoglobin estimation indicates that it is required.

Localized Abscess of the Liver is suspected.—If in a protracted case, it is considered possible that a sizeable abscess lies within the liver an exploratory operation should be performed (*see* p. 1138).

In a case operated upon successfully by the late Mr Litler Jones, of Liverpool, witnessed by me, two abscesses in the right lobe of the liver were drained. These were a sequel of suppurating hæmorrhoids.

LOCALIZED PYOGENIC LIVER ABSCESS

A pyogenic liver abscess can develop without any obvious cause indeed, in 77 cases analysed by W A. Bourne no cause was found in 42 and in these unexplained cases the abscesses were twice as often single as multiple. The chief symptoms are a hectic temperature with rigors, upper abdominal pain, respiratory disturbance, nausea, pain in the loin, and diarrhœa—in that order The local physical signs are downward enlargement of the liver and tenderness, but both these are absent in one-third of cases. Jaundice occurs in only one-quarter of cases. Radiological examination shows hepatic enlargement in three fifths of the cases. Leucocytosis is almost invariable, but *a blood culture is sterile in three-quarters of the cases*

A pyogenic liver abscess will often be missed unless the clinician is aware that it may be present in cases where no focus of origin is discoverable, and unless he relies on clinical and radiological examinations, rather than on pathological investigations.

Treatment.—The only treatment of a localized pyogenic liver abscess is drainage by open operation. *Operation.*—A transverse incision over the right rectus gives good access and is well suited for the erection of a barrier to prevent spread of infection to the general peritoneal cavity Unless placed deeply an abscess can be recognized by palpation there is an elevation on the surface of the liver and induration. After isolating the area most carefully with abdominal packs, an aspirating syringe fitted with a long wide bore needle is used to confirm the presence of pus. If pus can be withdrawn freely the barrel of the syringe is disconnected the needle being left in situ. To drain the abscess, sinus forceps are inserted along the track of the needle, which is then withdrawn. *The fingers should neither enlarge the opening nor attempt to break down loculi as is done in abscesses in other situations*, for this will cause tearing of the liver and serious bleeding The jaws of the forceps are opened sufficiently for a drainage tube to be inserted. The tube is fixed in position by a stitch which must be tied loosely or it will cut out.

If as is not infrequently the case the surface of the liver is found to be studded with small abscesses, and no large collection is found on aspiration, it must be conceded that the outlook is practically hopeless.

When it has been possible to drain an abscess in the liver it is very necessary to erect a barrier of omentum to shut off the general peritoneal cavity It must also be remembered that pus will ooze out alongside the tube and infect the space between the liver and the

costal wall. Drainage of this space must also be provided for. The patient should be nursed in the semi Trendelenburg position for several days to ensure that pus does not gravitate downwards into the general peritoneal cavity. After this time adhesions will have formed, and he can be propped up gradually.

THE ABDOMINAL CRISES OF PERNICIOUS ANÆMIA

At the present time the mistake of operating upon a patient with a tabetic gastric crisis is unusual. The surgeon who makes a routine practice of testing the reaction of the pupils and the knee-jerks in every suspected case of gastroduodenal perforation never falls into this trap. Less attention has been paid to another medical condition that simulates very closely an acute abdominal catastrophe.

The later stages of pernicious anæmia are occasionally complicated with what may be termed abdominal crises. These resemble so closely one of the recognized acute abdominal conditions, such as perforated gastric ulcer or acute pancreatitis, that, when confronted with a case of this kind for the first time, even a most conscientious surgeon may stumble. The pallor, especially in artificial light, is mistaken for that of profound shock or internal hæmorrhage, and when this picture is combined with a history of sudden *agonizing abdominal pain and vomiting, and is accompanied by abdominal rigidity,* the difficulty in diagnosis is at times insurmountable, unless, of course, we are in possession of the knowledge that the patient is suffering from pernicious anæmia. The explanation of the sudden attacks of abdominal pain is clear. During the katabolism of large numbers of erythrocytes the liver is called upon to excrete a prodigious amount of bile-pigment. These pigments are too concentrated to be held in solution, and are precipitated in the form of "bile mud," which gives rise to severe biliary colic. Furthermore, the subjects of these crises, being worn out by a long illness and an impoverished blood-supply, react very strongly to the painful stimuli.

Case 1.—A Jew, aged 33, was admitted at 2.30 a.m. as an "acute abdomen." He did not speak English, and the history was translated by a relative, who said that the patient was seized with sudden, very acute abdominal pain seven hours previously. The pain was at first in the epigastrium, *but later became general. He had vomited several times. As far as could be gathered* previously the patient had been quite well, except for indigestion. On examination the first observations were that he was exceedingly pale, and obviously he was in great pain. The abdomen did not move freely with respiration, and there was board-like general rigidity and tenderness, especially marked in the epigastrium and right hypochondrium. The liver, spleen, and kidneys could not be felt. The rectal examination and examination of urine were negative. The heart and lungs were clear. A diagnosis of perforated peptic ulcer was made, and laparotomy performed. The only abnormality found was a very distended gall-bladder. By cholecystostomy a large quantity of biliary mud was evacuated. Three days later the patient became comatose, and died shortly afterwards. It was at this time ascertained that he had received treatment a year previously for advanced pernicious anæmia.

Case 2.—A woman, aged 38, was admitted with a history extending over two years of frequent attacks of acute abdominal pain. The pain was always in the left hypochondrium and passed *through to the back. The present attack began four hours before* admission, and was considerably more severe than any of the previous ones; the patient had vomited. On examination in artificial light she appeared to be somewhat jaundiced. The tongue showed evidence of superficial glossitis. There was general abdominal tenderness and slight upper abdominal rigidity. The spleen and liver were enlarged, and the latter distinctly tender. A diagnosis of gall-stone colic was made. Next morning it was noticed that the patient was not jaundiced in the ordinary meaning of the term, but was of a bright lemon tinge. A colour index was carried out and gave a typical reading for pernicious anæmia. She was transferred to the medical side, where this diagnosis was confirmed.

THE ABDOMINAL CRISES OF PORPHYRIA

An increasing number of cases have been reported where the abdomen has been opened with negative findings, and the symptoms have been due to an abdominal crisis of porphyria. Porphyria is a hereditary error of katabolism of haemoglobin in which porphyrinuria occurs. The abdominal crises are characterized by violent colic, which *is liable to be* precipitated by the administration of barbiturates. These symptoms are produced by areas of intestinal spasm causing short segments of gaseous distension of the small and large intestine, and especially of the cæcum. Serial X-ray films often provide the diagnosis (G. A. Calvy). In obscure cases of intestinal colic with constipation, it is well to try

and remember this condition, especially when these symptoms are associated with photosensitivity or mental or neurological symptoms. Almost invariably the spleen is enlarged. The urine of these patients may be normal in colour; more often it is orange (which is often dismissed as concentrated). If a specimen of urine is left exposed to daylight for a few hours it becomes amber coloured, particularly near the surface where it is contact with the air. There are several conclusive laboratory tests for porphyrinuria. Another manifestation of acute porphyria is spasmodic abdominal pain, followed by jaundice. This is due to spasm of the common bile-duct and Oddi's sphincter (U. Ledingham).

Treatment.—Often there is a striking decrease in the serum-sodium level, and the patient is improved considerably by infusion of normal saline solution with careful control of electrolytic balance. To relieve the abdominal pain pethidine is the best drug. If a sedative is required, paraldehyde should be given.

Acute porphyria is a serious, and often fatal, disease, and in every acute attack megimide[1] (a barbiturate antidote) should also be given, irrespective of whether the attack is induced by barbiturates or not (T. K. With). Permanent remissions have been reported following splenectomy, which should be performed as an elective operation after a crisis has passed.

INTRAPERITONEAL RUPTURE OF A HYDATID CYST

In countries where hydatid cysts are rare, a correct pre-operative diagnosis of ruptured hydatid is improbable. In addition to symptoms of an acute abdominal catastrophe, urticaria and pruritus are frequently present. Eosinophilia in the circulating blood may be the means of clinching a tentative diagnosis.

Harold Dew's Case.—

E. B., a male of 45, was admitted in a state of severe shock, with a history that while he was lifting a weight he suddenly collapsed. The abdomen moved fairly well on respiration, but he was tender and rigid over the gall-bladder region. There was dullness in the flank as far medially as the umbilicus, and it moved with change of position. The diagnosis of visceral rupture was made, and the patient prepared for immediate operation.

The peritoneal cavity was found to contain much hydatid fluid and many daughter cysts of all sizes. A large multilocular cyst of the right lobe of the liver, adherent to the colon and gall-bladder, was found. This had a large opening on its postero-lateral aspect, at which point rupture had occurred. This cyst was evacuated and drained. The pelvis was then drained suprapubically by a large tube, after removing fluid and cysts as far as possible. The patient, for ten days after the operation, had a temperature of 102·5° F. (39° C.), rapid pulse, cough, dyspnœic attacks, and some delirium at night. It is probable that these symptoms were mainly anaphylactic in nature. For six weeks small cysts occasionally appeared through the suprapubic drainage track, but after being in hospital for two months, he was discharged, with instructions to report regularly and with a warning that probably secondary cysts would develop in a few years.

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[1] Nicholas Products Laboratories Ltd., Ethical Pharmaceutical Division, Buckingham Avenue, Slough, Bucks.

CHAPTER XXXIII

FOREIGN BODIES IN THE FOOD-PASSAGES

REMOVAL OF A FOREIGN BODY FROM THE ŒSOPHAGUS BY ŒSOPHAGOSCOPY

When a foreign body is impacted in the upper food passages, examination with a laryngeal mirror often shows a pool of saliva in one or both piriform fossæ of the pharynx. This is due to increased secretion of saliva, which is consequent upon the mechanical obstruction caused by the foreign body

Whenever possible, the presence of the foreign body is confirmed by radiography (*Fig* 454). If an operation is deemed necessary a second radiograph should be taken just prior to the operation thus we are armed with last-minute information concerning the foreign body which is liable to change its location. Non-opaque foreign bodies present a more difficult problem, and it should be emphasized that swallowed bones rarely contain sufficient calcium salts to render them radio-opaque In a proportion of cases where there is a history of swallowing some bone or other non-opaque body the ingestion of a small quantity of barium emulsion prior to an X ray examination may prove helpful. A typical radiological finding in such cases is as follows there is a residual barium flake, suggesting the presence of a foreign body " (F G Wrigley). It must be emphasized that the amount of barium ingested should not be more than half a teacupful. Even with this small amount in the stomach, a general anæsthetic should be postponed until the stomach is empty

Fig 454 —Coin impacted in the upper part of the œsophagus.

Fig 453 —Œsophagoscope with œsophageal forceps in situ.

The Technique of Œsophagoscopy—Before commencing œsophagoscopy review the apparatus (*Fig* 453). See that the lamp is working examine the œsophageal forceps, noting especially if the points of their jaws engage have a number of small pieces of gauze of a correct size to pass down the œsophagoscope in readiness—these are to mop up secretions, although they will be seldom required if a suction apparatus is available

The patient is anæsthetized, endotracheal anæsthesia being most desirable

Position of the Patient.—The position of the patient for œsophagoscopy is a most important consideration. The head-piece of the operating table is let down completely and the patient's head and neck are supported entirely by the seated assistant This allows the patient's head to be held firmly in any desired position. Note the following most carefully *During the passage of the œsophagoscope the patient's head should not be extended the assistant keeps the head well flexed.* It is only when the instrument is within the thoracic portion of the œsophagus that the head is lowered. Meticulous observation of this rule very materially aid in œsophagoscopy

Passing the Œsophagoscope—The mouth is opened and the tongue is drawn out by the anæsthetist The exterior of the œsophagoscope is smeared with a little sterile paraffin.

The operator stands. With the handle of the instrument directed upwards, the œsophagoscope is passed along the right side of the tongue until the posterior pharyngeal wall is reached (*Fig* 456) A lifting motion is imparted to the beak of the instrument and this will bring the right arytenoid cartilage into view The advancing tip of the œsophagoscope is lifted over this structure and the instrument directed to the right (usually) or the left piriform fossa, so as to imitate the mechanism of swallowing It glides on for a short distance then comes to a stop: this is the cricopharyngeal constriction (*Fig* 457).

Fig 456 —Introducing the œsophagoscope. First stage Negus œsophagoscope being used.

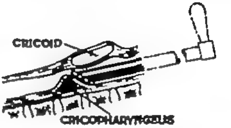

Fig 457 —Passing the cricopharyngeal constriction, the most difficult part of œsophagoscopy The importance of keeping the handle of the instrument uppermost during the manipulation can be seen

A little steady pressure with a lifting motion imparted to the distal end of the œsophagoscope by the left thumb within the mouth overcomes the obstruction. The instrument is now within the thoracic portion of the œsophagus, along which it passes with comparative ease. Directly the cricopharyngeus has been passed the patient's head may be lowered somewhat, and the operator who has been standing takes a seat low enough to allow his eye to peer down the œsophagoscope without inconvenience (*Fig* 458 A).

When radiographic evidence is available we will know where to expect the foreign body on approaching this region the instrument is advanced slowly A coin is sometimes

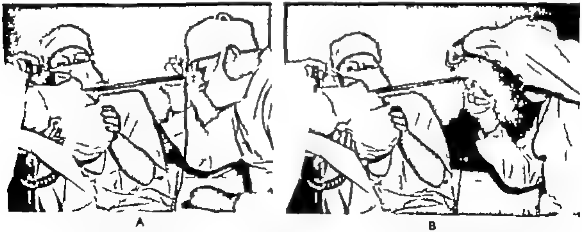

Fig 458.—A, The œsophagoscope is within the upper œsophagus and is being advanced slowly B The foreign body (denture) has been visualized, and is being grasped with alligator forceps.

buried in food When the object is seen (*Fig* 458 B) it must be manœuvred with the closed forceps, or by moving the œsophagoscope slightly backwards and forwards, until an edge suitable for grasping presents. The forceps then seizes the body (*Fig* 459), and, still grasping it the forceps, œsophagoscope and foreign body are removed *en bloc*. In a small series of cases which include three dentures and more than a dozen coins, only the simple alligator forceps (*see Fig* 453) were used, and were found to be perfectly satisfactory

Some Difficulties of Œsophagoscopy.—

Light Anæsthesia.—If the patient starts gagging, anæsthesia is not deep enough, and it is dangerous to proceed. Remove the instrument, and when the patient is fully anæsthetized, start again. If the services of a skilled anæsthetist are available the injection of curare-like drugs (e.g., scoline) so relaxes the cricopharyngeal sphincter that œsophagoscopy is considerably facilitated.

The Foreign Body is not Visible.—It is possible for a foreign body to be hidden by a fold of mucous membrane (*Fig.* 460) and this is most likely to occur just distal to the cricopharyngeus. If, after an adequate search, the object cannot be seen, remove the œsophagoscope and having reinserted the instrument, scrutinize the whole course of the œsophagus once more. On one occasion a second search failed to reveal a denture which had been swallowed. The patient had been radiographed elsewhere earlier in the day and brought a film showing the denture in the mid-œsophagus. Still under the anæsthetic, the patient was moved to the X-ray room, and there screened. The teeth were in the stomach. On return to the theatre the denture was removed by gastrotomy. This emphasizes the wisdom of not accepting X-ray evidence unless it is of very recent origin.

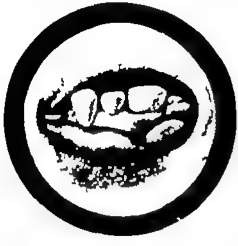

Fig. 459.—A denture in the œsophagus as seen through an œsophagoscope.

Fig. 460.—Coin hidden by a fold of mucous membrane.

The Problem of the Safety-pin.—An open safety-pin with the point downwards offers no particular difficulty. The coiled spring is seized, and the pin drawn into the open mouth of the tube (*Fig.* 461). In the case of a small safety-pin with the point upwards, version may be tried, but always, and only, in the direction which will cause the point to trail (*Fig.* 461). Once the coiled spring is uppermost it can be drawn into the œsophagoscope. The safety-pin *with the point upwards* is a more difficult problem. Intra-œsophageal version must not be attempted: the safety-pin should be pushed gently downward into the stomach with alligator forceps. A skilled œsophagoscopist can perform gastric version and then remove the pin endoscopically. However, having guided the safety-pin into the stomach, most surgeons should be content with removing the open safety-pin by performing gastrotomy (*see Fig.* 464).

Fig. 461.—A safety-pin must always be withdrawn spring first. In the case of a small pin pointing in the wrong direction, version may be attempted, but always in the direction shown in inset—i.e., the point must trail.

PERFORATION OF THE ŒSOPHAGUS BY A FOREIGN BODY

There is always the danger of a foreign body, particularly a pointed or jagged object, perforating the œsophagus. This is the chief reason for pressing that a foreign body in the œsophagus be removed by œsophagoscopy as soon as possible rather than waiting

in the hope that it will pass into the stomach. Retrosternal or interscapular pain suggests perforation, and the great danger of perforation of the œsophagus is spreading mediastinitis.

Radiography.—A lateral radiograph is still important. The demonstration of air in front of the spinal column, usually between the spine and the trachea, is pathognomonic. Thickness of the tissue layers between these structures suggests an inflammatory reaction. A small bubble of air is often displayed in the œsophageal lumen at the site of the foreign body, and is of no diagnostic significance. On the other hand, a large air bubble indicates a peri-œsophageal abscess, but does not exclude an abscess of the œsophageal wall. A rather long streak of interstitial emphysema is a sure sign of perforation. In cases of perforation of the lower third of the œsophagus a pneumothorax is sometimes present.

Treatment.—The foreign body should, of course, be removed as soon as possible. There is a great deal of evidence that antibiotic therapy combined with drip feeding through an indwelling intragastric tube for a week, will prevent spreading infection and cure peri-œsophagitis. Perforation, therefore, does not necessarily indicate the need for immediate thoracotomy, although when an obvious perforation is found while performing œsophagoscopy it is wise to open the thorax and suture the perforation. In most cases, when perforation is merely suspected, if the foreign body is removed early, antibiotic therapy and intragastric feeding usually render thoracotomy unnecessary. Late cases that have escaped spreading mediastinitis may require drainage of an abscess of the posterior mediastinum.

INGESTED FOREIGN BODIES IN THE INTESTINE AND STOMACH

A foreign body has been swallowed. The problem before us has been simplified by X rays, but there remains a considerable amount of judgment to be exercised in deciding whether the foreign body should be left, to see if it will be voided, or be removed by operation. At this juncture it is well to know that F. H. Kemp cites two instances where a foreign body in the œsophagus was missed owing to X-ray examinations being confined to the abdomen.

In assessing whether a blunt object will pass through the alimentary canal the following data are helpful: a halfpenny, which is 1 in. (2·5 cm.) in diameter, almost always passes in a child aged 3. In children aged 2 or under, a halfpenny is nearly always arrested at the pylorus. Contrary to expectation, the relatively narrow portions of the alimentary canal, viz. the cardiac orifice, the pylorus, and the ileocæcal valve, are not the most common sites of arrest. In most series of collected cases the lower ileum and cæcal portions of the intestine are the most frequent sites for a hold-up; on the contrary, in sixteen consecutive cases of swallowed objects, G. O. Chambers, visiting surgeon to H.M. Prisons, found that the majority of reasonably large foreign bodies pass the pylorus and the ileocæcal valve, to become impacted in the large intestine. The average time taken by a foreign body to pass through the alimentary canal is six days (A. H. Siddons).

Fig. 402.—With normacol, suet puddings, and enemata this foreign body passed through the alimentary canal uneventfully. Daily radiographs were taken.

Radiographs, repeated at intervals, are essential. In cases where the foreign body is of such a shape as to be a menace, not more than six to ten hours should intervene between the examinations. The patient should continue with his normal diet. *Purgatives and enemata must be eschewed rigorously*; on the other hand, a good method is to administer normacol, two or three drachms every six hours, until the object has been expelled (*Fig.* 402). Normacol is a proprietary vegetable laxative which swells enormously when it

comes into contact with water It forms in the alimentary canal a gelatinous mass in which *the foreign body is likely to become entangled. Small quantities of liquid paraffin* may be given with safety

A partial denture with hooks is better removed without delay Regarding pins, needles, and nails, provided the patient is under constant observation there appears to be little danger in awaiting radiological evidence of their arrest A. H. Siddons reported a series of 35 cases of ingested pins or needles. All except three were passed naturally while the patient was under radiological observation in hospital In the three in which an operation was considered necessary the object was removed before perforation occurred.

The great point is that the patient should be under constant observation If the *passage of a sharp foreign body is delayed at any point for several hours, it should be removed* by operation. J A. Macewen recorded a case of a soldier who died of general peritonitis from a pin piercing the cæcum. In the case of an ingested radium needle, the danger of radium necrosis as a cause of perforation should accelerate the decision to operate.

Perforation by a Foreign Body.—Of 90 cases collected by W R. McKechnie the location was as follows —

Gastroduodenal region	5
Lower ileum	10
Meckel's diverticulum	10
Appendix	33
Cæcum	10
Hepatic flexure	3
Transverse colon	1
Splenic flexure	2
Descending colon	1
Sigmoid	5
Rectum	8
Foreign bodies found in an abscess on laparotomy	7

The mortality following removal of the foreign body by operation and drainage of the peritoneal cavity was 23·9 per cent.

It will be noted that the stomach is not listed perforation of the stomach wall by an ingested foreign body must be very rare; F H Kemp recorded an example occurring after the patient had been given a purgative that made him vomit.

LAPAROTOMY FOR AN INGESTED FOREIGN BODY

A very recent radiograph must be at hand. Once the foreign body within the intestinal lumen has been located by the fingers, and especially if it is small, the hold upon it should not be relaxed. The better to uphold this principle, if necessary the assistant can help in packing off the area, a procedure of great importance.

Fig. 463.—Whistle impacted in the pylorus.

The removal of a foreign body from the gut follows recognized surgical principles. It suffices to say that the field of operation must be isolated by packs, a clamp should be applied whenever possible to avoid escape of fæces, and the gut closed by a purse-string suture in the case of an elongated body removed through a minute incision. When it is necessary to make an incision of half an inch (12·5 mm.) or more the hole should be sewn up transversely in two layers.

In the Stomach.—Operation is advised: (*a*) When the foreign body is judged to be too large to pass the pylorus; (*b*) If it has failed to pass the pylorus after two days (*Fig* 463) or (*c*) If it is of a dangerously spiked nature The upper abdomen is opened and the stomach palpated for the object. When found it is manipulated against the anterior gastric wall, and if of appreciable size such as a coin, a stomach clamp is adjusted beneath it After arranging abdominal packs, a small incision is made and the foreign body extracted (*Fig* 464). The stomach is closed in two layers. Within reason the larger the

TECHNIQUE OF THE REMOVAL OF A PIN FROM THE GUT

After isolating the segment of intestine with packs, by manipulation the point of the pin is made to protrude through the intestinal wall. As soon as the point appears it is grasped with a hæmostat (*Fig* 467) the fingers do not touch the infected metal. A purse-string is inserted around the perforation, and with a firm tug out comes the pin. The purse-string suture is then tied. *The nail in Fig 468 was removed in the same way*

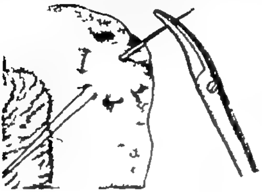

Fig 467 —Method of extracting a pin from the intestine

Fig 468 —Radiograph of a nail impacted in the colon t the hepatic flexure. Removed by the technique shown in *Fig.* 467

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CHAPTER XXXII

INTRA ABDOMINAL INJURIES

SOME GENERAL PRINCIPLES

THE history of the mode of injury is highly important. Street accidents are the most frequent cause blows or kicks on the abdomen come second ; falls from a height contribute a smaller quota. Another type of accident is the crushing variety such as when a man is caught between a truck and a loading platform. Lastly seemingly slight accidents such as falling against the edge of a table sometimes result in serious visceral injury

The diagnosis of non-penetrating intra abdominal injury is often rendered far more difficult when it is associated with more obvious injuries that tend to divert the attention from the abdomen. Even in the absence of other injuries, the diagnosis of serious damage to an intra-abdominal structure is usually not possible soon after the accident. At this stage the severity of the pain is often not in keeping with the severity of the abdominal lesion. The same is true of tenderness on palpation. In these cases two or three hours of vigilant observation is necessary (*a*) to come to a definite conclusion as to whether laparotomy is required and (*b*) to strive by clinical examinations to determine which organ is damaged.

A severe blow to the abdomen causes immediate shock and discomfort that is likely to persist for some time even when no serious intra-abdominal injury is present. Conversely quite often the patient appears to recover from the immediate effects of the trauma only to develop signs of visceral injury later This period of illusion makes close observation imperative. Every patient brought to hospital shortly after an abdominal injury should be detained. Even in seemingly slight injuries he should be observed for at least six hours, and if thought fit to be discharged, he should be given written instructions to report if he experiences abdominal pain, vomiting, weakness, or shortness of breath on exertion.

Detailed observation will include a half hourly pulse-rate, hourly determinations of the blood pressure, and at least two careful examinations of the abdomen. Usually injury to the bladder or the kidney can be eliminated by obtaining a specimen of urine, if necessary by catheterisation should the urine be clear it is good presumptive evidence that the urinary organs have escaped serious damage. This preliminary step should never be omitted it is also advisable to examine the specimen microscopically for blood.

Early Treatment of Shock.—If shock is present, therapy should be started immediately as it will not interfere with the local physical signs. Infusion of dextrose-saline (or in severe cases dextran or plasma) should be started at once. If necessary blood transfusion should be carried out as soon as possible in any case, a specimen of blood for cross-matching is procured.

Morphine or other narcotics should not be administered before the diagnosis is established. Although morphine is acknowledged to be an excellent drug in the treatment of shock it is liable to confound the diagnosis by masking the early signs of peritoneal irritation, e.g., abdominal pain and tenderness. Under these conditions morphine may jeopardize a successful outcome. The practice should be to withhold morphine until a decision has been made for or against the necessity for laparotomy In cases of early profound shock without evidence of external bleeding of sufficient degree to account for it, intraperitoneal bleeding must be presumed. If the abdominal signs and symptoms agree with this presumption, the decision to operate as soon as possible is imperative.

Gastric Aspiration should be employed as soon as possible whenever there are signs of an intra-abdominal injury This is valuable for several reasons. The aspirate may contain blood this is presumptive evidence of injury to the stomach or duodenum. Gastric aspiration alleviates acute dilatation of the stomach, which often comes on early in these cases. It also prevents, or at least mitigates, abdominal distension should paralytic

ileus develop seeing that most of the distension in these cases is due to swallowed air Aspiration of the contents of the stomach reduces the anæsthetic hazard, and the fact that the stomach is empty is a distinct asset to the surgeon exploring the abdomen.

Radiography.—Plain films taken in the supine and upright positions are most desirable. A film of the thorax is also helpful. Recognition of a fracture of a rib or ribs, the pelvis, or lumbar spine and transverse processes, confirms the occurrence of severe trauma, and directs attention to nearby structures as probable sites of injury Loss of both psoas shadows is indicative of the presence of free peritoneal fluid. The presence of free air under the diaphragm is proof positive of perforation of some portion of the gastro-intestinal tract. Acute dilatation of the stomach produces a large bubble in the left upper quadrant, and may be difficult to differentiate from gas beneath the diaphragm—a ready solution of the problem is gastric aspiration. Gas in the retroperitoneal tissues is diagnostic of intestinal perforation in one of the retroperitoneal areas, viz., duodenum or ascending or descending colon. The presence of subcutaneous emphysema from thoracic injury can give the same radiological appearance, but the latter can be excluded easily by clinical methods. *A localized collection of blood or other fluid at times casts a shadow in the* radiograph. Paralytic ileus with air fluid levels may result directly from the initial trauma, or it may indicate spreading peritonitis.

Two supine films, even though taken a few moments apart, are more instructive than one, perhaps owing to minor differences in technique. A film in the erect position is highly desirable if the patient's condition permits. In lieu thereof a film is taken in the left lateral position. Gas beneath the diaphragm if the patient is erect, or beneath the liver if the patient is in the left lateral decubitus, when present, is of great diagnostic significance As little as 4 ml of free gas will show

Useful as it is in the diagnosis of intra-abdominal trauma, too much trust must not be placed in radiography In the great majority of cases of both hæmoperitoneum and rupture of the intestine the films are negative.

Diagnostic Aspiration of Peritoneal Fluid can be carried out with very little risk if a fine gauge needle is used. This method of attempting to arrive at a diagnosis of hæmoperitoneum is justified particularly when abdominal injury is complicated by other injuries, especially concussion. The needle is entered a fingerbreadth below the left costal margin towards the flank if that is negative, below the right costal margin. Three or four punctures in these regions may be required before concluding that there is no free blood present in the hypochondrium. Hollow needle paracentesis of the iliac fossæ is less desirable, and should be employed only when there is dullness to percussion after the hypochondria have been tapped with a negative result, and when, because of other injuries, *exploratory laparotomy is to be avoided, if possible.* This test has been estimated as being 83 per cent accurate in establishing a diagnosis of intra-abdominal hæmorrhage (H S Collier).

Exploratory Laparotomy.—In most cases up to two hours can be spent in endeavouring to improve the patient's general condition but it should be remembered that in cases of serious intra-abdominal trauma the response to the treatment of shock is often evanescent, and a short period of recovery is followed by a relapse. During the period of recovery from shock, usually it is possible to arrive at a diagnosis, but at times, in spite of the risks of laparotomy it is impossible to eliminate the possibility of an intraperitoneal lesion by any means other than full exploration. Examples are as follows: (*a*) The effects of retroperitoneal bleeding associated with fracture of the pelvis or the lumbar spine can be indistinguishable clinically from an intra-abdominal lesion (*b*) After finding an extraperitoneal hæmatoma due to a torn epigastric artery which was ligated, J P Cogley opened the peritoneum to discover a rupture of the small intestine

Blood Transfusion.—By employing blood transfusion, in most instances, even in patients with severe intra-abdominal injuries, it is possible to commence the operation with the patient not only having a normal blood pressure but also warm, pink extremities. When possible homologous blood should be available in adequate quantities, and if the patient is obviously bleeding internally blood should be running, preferably into two veins, at the time of making the laparotomy incision. Multiple major injuries associated with traumatic hæmoperitoneum is an occasion on which to employ arterial transfusion.

Traumatic Hæmoperitoneum.—On opening the abdomen, *if blood and blood-clot* are in evidence, survey the situation rapidly as follows, bearing in mind the excellent aphorism, *follow the clots* Usually the source of the hæmorrhage is soon apparent —

1 Palpate the spleen.

2. Palpate and inspect the under surface of the liver

3. Pass the hand over the convex surface of the liver

4 Examine the mesentery This can be done by lifting out one or two coils of small intestine and observing the inferior and left aspect of the mesentery and then passing the finger upwards and downwards over the surface Even small tears will be detected in this way After a tear has been found and repaired, the whole of the mesentery must be scrutinized (see p. 378).

5. Palpate the kidneys (intraperitoneal rupture is exceptional).

6. Re-examine the spleen, paying special attention to its pedicle.

7 Pass the hand into the pelvis. I detected a tear in the broad ligament at this stage in an obscure case of traumatic hæmoperitoneum. More blood in the pelvis than in the rest of the abdomen suggests a lower abdominal lesion Nevertheless, pre-operative Fowler s position renders the value of this sign less significant.

8. Examine the great omentum and transverse mesocolon.

9 Open the lesser sac between the stomach and colon and inspect the pancreas. However an extravasation of blood into the lesser sac will be obvious at a very early stage of the examination.

RUPTURE OF THE SPLEEN

Ruptured spleen is the commonest injury caused by non-penetrating violence to the abdominal wall. In the great majority of instances it is a solitary lesion, but because it is occasionally associated with other intra-abdominal lesions requiring surgical attention (most frequently injury of the tail of the pancreas, or rupture of the left kidney) the rule to explore the whole abdomen can never be relaxed

The nature of the violence was evident in 32 cases that I reviewed —

Street accident—run over or knocked down by a vehicle	14
Fall on to a projecting object, e.g., the corner of a table	7
Kicked in the abdomen	3
Fall from a height	3
Buffer accident (compression)	3
Fall over handlebars of pedal cycle	2

Cases of rupture of the spleen are divided into three classes —

1. **Rapid Succumbing of the Patient** is uncommon. Complete avulsion of the spleen from its pedicle is the type of accident which is most likely to give rise to the symptoms that characterize this group

A boy aged 5 was run over and was admitted to hospital in a state of profound shock. In spite of resuscitative measures, he died two hours later At necropsy the peritoneal cavity was found to be full of blood, and the detached spleen was discovered lying on the fundus of the urinary bladder

2. **Shock—Signs of Rupture.**—This is the largest group and about three-quarters of the total cases belong to it. After the initial shock has passed off, there are signs which point to a serious intra-abdominal disaster It is not always possible to state precisely which organ is damaged, but in the majority of instances the physical signs should point clearly to the spleen as the site of the injury

The patient is pale. Often the abdomen is slightly distended. Abdominal rigidity is variable ranging from generalized rigidity to that localized to the left upper quadrant and extending towards the flank. Abdominal tenderness is likewise variable commonly it is present in the left upper quadrant, and frequently pain is accentuated by deep breathing In early cases the pulse-rate may not rise above 90, and the blood-pressure is often comparatively unaltered for several hours. Referred pain to the tip of the left shoulder (Kehr's sign) is a valuable sign that may be induced by having the patient lie flat with the foot of the bed raised (T C. O Connell). In a number of cases the sign is present, but abdominal pain is so much more in evidence that the patient does not mention the shoulder pain unless he is asked about it.

The usual history of rupture of the spleen conforms to a definite pattern. Trauma to the abdomen or lower thorax is followed by a latent period of six to ten hours in which the patient has symptoms of an indefinite nature or may be symptom free only to collapse suddenly from intra-abdominal hæmorrhage. Should the patient reach hospital during the latent period a varying degree of shock is found, and treated. If the intra-abdominal hæmorrhage is slow or intermittent this treatment will support the blood-pressure, and the blood-count will remain close to normal thus masking the general signs of internal hæmorrhage.

Radiography can assist in the diagnosis of ruptured spleen. In plain radiographs of the abdomen the spleen is visible in whole or part, especially when the stomach and the splenic flexure contain gas. When the spleen is ruptured this outline is partially or completely obliterated. The stomach may be displaced medially and the splenic flexure downwards. Retroperitoneal hæmorrhage is likely to obscure the psoas shadow and this sign is present in about 30 per cent of cases. In a series of 27 consecutive cases, 10 had fractured ribs (R. Clarke).

3. The Delayed Type of Case.—After the initial shock has passed off the symptoms of a serious intra-abdominal catastrophe are postponed for 48 hours to weeks or even months.

A navvy aged 40 was hit in the upper abdomen by a pole. He fainted, but soon recovered sufficiently to walk to hospital, where he was examined and told to report the next day. On the morrow he felt better and stayed at home. Five days later he was brought in with well-marked signs of internal hæmorrhage having collapsed at home a few hours before admission. Splenectomy was performed successfully.

Straining at stool, vomiting coughing or a full meal, will frequently furnish the mechanism to restart the hæmorrhage.

Delay of serious bleeding is explained in one of three ways. (1) The great omentum performing its well-known constabulary duties, shuts off that portion of the peritoneal cavity in the immediate vicinity of the spleen. (2) A clot seals the rent temporarily. (3) There is a laceration of the parenchyma within an intact capsule: a subcapsular hæmatoma forms, and later bursts. It is probable that each of these three factors, at one time or another temporarily arrests serious hæmorrhage.

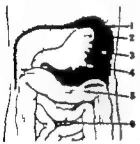

Fig. 469.—Radiographic signs of (delayed) rupture of the spleen. 1. Left diaphragm raised. 2. Stomach dilated; 3. Opacity in the left hypochondrium; 4. Indentation of the stomach. 5. Transverse colon displaced downwards. 6. Fluid between the coils of intestine. (*After* ? *F. S ker.*)

In the delayed type of case the aim should be to diagnose the condition before the hæmatoma bursts, and provided the patient is under observation, this can sometimes be accomplished, for:—

1. In patients with delayed hæmorrhage the red blood-cell count and hæmoglobin estimation are consistently low and give a more accurate picture of the abdominal condition than in those with immediate hæmorrhage and shock. During the latent interval the pulse rate seldom returns to normal and usually there is some pain in the left hypochondrium.

2. As the entity delayed rupture of the spleen has become more generally recognized, various X-ray signs have been described. *Fig.* 469 depicts all the radiological signs. In a given case only one or two of them is likely to be present. With such aid, it is occasionally possible to arrive at the diagnosis before the catastrophic hæmorrhage occurs.

In the delayed type of case a point worthy of earnest consideration is the baffling friability of the splenic pedicle which is encountered. The explanation of this phenomenon is fairly clear. The pedicle, after being surrounded by mildly infected blood and blood-clot for a varying time itself becomes œdematous, and *commences to undergo degeneration*. It is thus more likely to be found in those cases in which serious hæmorrhage has been postponed by an omental barrier.

It behoves us, therefore when dealing with the delayed case, to take particular care to avoid the cutting-out of a ligature. A mass ligature is more likely to cut out than a series of smaller individual ligatures applied by transfixion with a sewing needle close to the spleen. Further precaution is necessary to avoid losing a pedicle which has cut out. C. H. Mayo immortalized the slipped renal pedicle which, he said, "fairly jumps into the fingers" when nimble fingers promptly follow its retraction into the depths of the wound. If the lieno-renal ligament with its vascular contents, slips or cuts through,

it might be possible to retrieve it by the same means. A better practice is to compress the splenic artery and vein (*Fig* 470) as Andreasen describes in his chapter on ABDOMINAL EMERGENCIES IN THE TROPICS (Chapter XCIII).

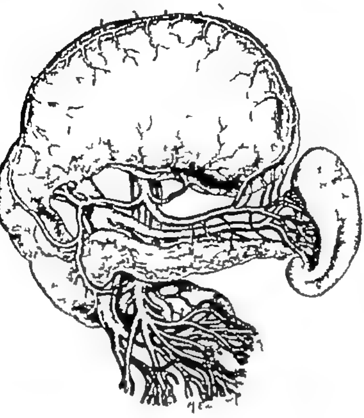

Fig 470—The disposition of the splenic vessels. (*After Hellmann.*)

Operation.—

The Incision.—The left paramedian incision is justly popular for splenectomy Nevertheless, in an emergency the supra umbilical midline incision offers certain advantages. Foremost among these is the speed with which the abdomen can be opened or closed. That the midline incision is usually adequate for removal of a ruptured spleen (*Fig* 471) is, I think, well illustrated by one of my patients, a fat, barrel-chested man of 52, from whom the spleen was removed successfully by this route. In those rare instances where more room is required in order to deal with an adherent organ, the incision can be enlarged by a transverse cut to the left Especially in the delayed type of case is a transverse incision effective. This incision, while it takes longer to close securely gives excellent access to the splenic pedicle

Fig 471—Ruptured spleen removed successfully from a man of 52.

Technique of Splenectomy for Rupture—The left hand is passed into the wound and the spleen is palpated. Generally a tear can be felt on the convex surface of the organ. The fingers are passed over the convex surface and thence they seek the pedicle.

A retractor is placed in the left side of the wound, and sufficient blood and blood-clot is wiped away to see the spleen. The organ is now brought gently towards the mouth of the wound. Usually it comes up without difficulty and can be delivered, without any tension, through a midline incision, especially if there is good retraction of the left side of the wound. If any resistance to delivery is encountered, the fingers of the right hand are at once available to enter the wound, pass over the convex border (*Fig.* 472), and find out the nature of the adhesions that are preventing easy delivery. If adhesions are considerable the wound must be enlarged by a transverse cut to the left, in order that these adhesions may be separated or divided under vision. As has been emphasized already this step is hardly ever required in the treatment of ruptured spleen as it is seen in temperate climates.

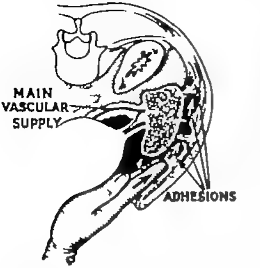

Fig. 472. — Method of separating minor and friable perisplenic adhesions. (*After J. E. Dunphy.*)

If necessary an abdominal pack is inserted into the inferior portion of the wound to keep the colon out of the way. The spleen is now under vision. A little systematic swabbing will render the boundaries of the organ clear. The organ is rotated so that the diaphragmatic surface is directed towards the right; this exposes the splenic vessels entering the hilum. By elevating the inferior pole the pedicle is displayed. Clipping then cutting (*Fig.* 473), little by little and keeping close to the spleen—cutting at the expense of the spleen if necessary—the organ is removed. We now have the pedicle secured by a number of hæmostats; losing it is impossible. Each moiety of tissue grasped by the forceps is transfixed with a needle and ligatured. After making certain that the cut surface of the pedicle is dry it is allowed to fall back.

The technique is simple. It does away with the necessity of mass ligature where as it were all the eggs are placed in one basket. There are no catastrophes from cutting out or breaking of the ligatures. The grip of the pedicle between the finger and thumb and the small amount of tissue ligatured at one time minimize the risk of injuring the tail of the pancreas. There is nothing brilliant about the method—but it is safe.

Fig. 473.—Splenectomy for rupture. By clipping then cutting, little by little the pedicle is divided, keeping close to the spleen.

If the anæsthetist reports all well, a few minutes can be expended in removing blood from the peritoneal cavity. The hands, hollowed in the form of a scoop, are the most efficient apparatus for removing fragmented clot.[1] Palpation of the liver will ensure that a concomitant rupture of that organ is not overlooked. The tail of the pancreas is next examined. Finally the intestine is scrutinized. If the pancreas is damaged many complications are minimized by a drainage tube brought out on the left flank. If it is intact no drainage is necessary. The abdomen is then closed.

Transfusion.—The ideal method is to transfuse the patient with matched blood before, during and after the operation. If matched blood is not available and provided ruptured

[1] Every fragment of ruptured spleen must be removed, in order to prevent autogenous grafting of splenic tissue (splenosis).

intestine is excluded autotransfusion of blood removed from the peritoneal cavity is another method of replenishing the circulation. The blood is collected, mixed with citrate solution, filtered through four thicknesses of gauze, and returned to the patient's vein. Collection of extravasated blood from the peritoneal cavity is somewhat time consuming especially when the incision is an upper abdominal one. The procedure is facilitated by a suction apparatus. It must be taken for granted that there is the necessary skilled assistance at hand if this method is to be used.

In extenuating circumstances the infusion of dextran solution or plasma must be substituted for the more ideal method of blood transfusion. A good method for the single-handed surgeon is to commence the operation by inserting the cannula of a continuous intravenous infusion apparatus into a vein and allow dextrose-saline to be absorbed during the operation. Using this method I have opened the abdomen under local anæsthesia and performed splenectomy for rupture after an unskilled assistant had injected a small dose of pentothal into the saline delivery tube.

Fig. 474.—A gridiron incision was used to explore the abdomen in this case. On opening the peritoneum blood poured out. The incision was therefore closed and a midline upper abdominal one substituted, through which the spleen, which had ruptured spontaneously, was removed.

Rupture of the Splenic Vein.—I have met with three examples of this condition. In each the peritoneal cavity contained dark portal blood. On palpating the spleen and finding it intact one naturally thinks that the portal hæmorrhage is coming from the liver, only to be disillusioned when the latter organ is examined thoroughly. Under these circumstances observe the splenic pedicle. This was the source of the bleeding in the cases to which I refer. Ligature of the splenic pedicle and splenectomy was followed by recovery in all three cases.

Spontaneous Rupture of a Normal Spleen.—Several examples have been reported. Such a case was encountered in a man aged 20. The symptoms came on while he was seated by the fireside at home. Admitted to hospital 18 hours later tenderness was most marked in the right iliac fossa (*Fig. 474*). The spleen was normal on macroscopical and microscopical examination. There is evidence to support the contention that spontaneous rupture never occurs in a normal spleen, but that some form of trauma has occurred which the patient has forgotten or wishes to conceal.

Dual Lesion (ruptured spleen and left kidney).—(*See* p. 387.)

Triple Lesion (ruptured spleen, left kidney and lacerated diaphragm).—(*See* p. 387.)

COMPLICATIONS AFTER SPLENECTOMY FOR RUPTURE

Peritoneal Effusion.—Peritoneal effusion amounting to ascites was seen in one of my cases. It was noted on the eighth day after operation, and was accompanied by slight pyrexia. The fluid began to lessen in amount about the fourteenth day, but was demonstrable until the end of the fourth week. Its presence can be accounted for by an overlooked laceration of the pancreas. Routine drainage will prevent this complication.

Burst Abdomen.—The wound disrupted and had to be re-sutured in 4 of the 32 cases that I reviewed. The most feasible explanation is that pancreatic ferments digest the edges of the abdominal wound and the catgut contained therein. The tail of the pancreas may be wounded when splenectomy is being performed, or as is probably more usual, it is injured together with the spleen at the time of the accident. There is good authority for the latter conjecture, for at the necropsy of one patient with ruptured spleen who died without operation the tail of the pancreas was found to be almost severed. The use of stainless steel wire for closing the wound would reduce the incidence of this complication.

Left Pleural Effusion.—A left-sided pleural effusion requiring aspiration occurred in three instances in the same series.

Persistent Hiccup.—Persistent hiccup lasting more than five days and preventing sleep, seriously complicated the convalescence of one patient. Hiccup is probably due to irritation of the branches of the left phrenic nerve on the under surface of the diaphragm.

Anæmia.—Mild secondary anæmia may follow removal of the normal spleen. This may necessitate transfusions in the early weeks of convalescence, but adjustment of the hæmopoietic system soon occurs.

RUPTURE OF AN ANEURYSM OF THE SPLENIC ARTERY

This is very rare and almost impossible to diagnose with certainty. A pre-operative diagnosis of hæmoperitoneum, probably spontaneous rupture of the spleen, is creditable. Unfortunately the possibility of a coronary thrombosis sometimes cannot be eliminated, except by electrocardiography.

While the incidence is about the same in either sex, it is noteworthy that about 25 per cent of female patients were 6–8 months pregnant at the time of the rupture of the aneurysm.

Treatment.—As can be imagined, hæmorrhage from a ruptured aneurysm is likely to be torrential, more especially after surrounding clot has been disturbed; consequently if possible almost the first consideration is to arrange for massive blood transfusion, which is commenced in the ward before the patient is taken to the operating theatre. Excision of a comparatively small aneurysm situated near the hilum, together with a normal spleen, presents no difficulty; a large aneurysm tends to burrow behind the pancreas. *Proximal ligature of the splenic artery alone is useless*, for the collateral circulation of the spleen is such that the aneurysm continues to bleed from its distal end.

Method of Procedure in All Cases.—(*a*) After entering the lesser sac between the greater curvature of the stomach and the transverse colon, ligate the splenic artery proximal to the aneurysm. (*b*) From within the greater sac, ligate the splenic pedicle near the hilum of the spleen.

Splenectomy, although often performed, is unnecessary.

So far, only 3 patients with a ruptured splenic aneurysm have been saved from death. On the other hand, 4 with catastrophic hæmorrhage from the region of the hilum of the spleen, due, it was thought, to the giving way of an atheromatous patch in the wall of the splenic artery, have been recorded. They all recovered after proximal ligation of the splenic artery and splenectomy.

SPONTANEOUS INTRA-ABDOMINAL APOPLEXY

Intraperitoneal hæmorrhage not due to trauma, a ruptured ectopic gestation or tubal abortion, nor yet to spontaneous rupture of the spleen or a rupture of an aneurysm of the splenic artery, is most perplexing, and an operator unacquainted with the condition known as spontaneous intra-abdominal apoplexy may well be nonplussed.

Most cases have occurred in patients with hypertension, and in a number of instances (mostly fatal) the source of the hæmorrhage has not been discovered. The commonest known site is the left gastric artery; the next most common is the right gastric artery (*Fig.* 473).

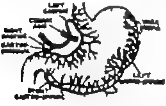

Fig. 473.—Showing the left and right gastric arteries.

R. Burkitt's Case.—

A man of 50 suddenly experienced excruciating pain in the left abdomen. On admission one hour later he was still in great pain, and was suffering from shock. The abdomen was rigid and tender, and on the left side shifting dullness could be elicited. The abdomen was opened by a left paramedian incision; the peritoneal cavity was filled with blood. As this was being aspirated a search was made for the bleeding point. The spleen, the splenic pedicle and the liver were examined with negative result, and in spite of blood transfusion the patient's general condition deteriorated rapidly, his pulse becoming imperceptible. As the bleeding appeared to be coming from the upper abdomen, the free edge of the gastrohepatic omentum was compressed (*see Fig.* 480, p. 375). Blood no longer welled up. Keeping the fingers in this position, the abdomen was emptied of blood; the grip was relaxed, and a spurt was seen to come from the right gastric artery about 1 in. (2.5 cm.) from the pylorus. The artery was secured and ligated. The abdomen was closed. The patient, who was not hypertensive, made an uninterrupted recovery.

RUPTURE OF THE LIVER

There is a great similarity between the clinical features of rupture of the liver and those of rupture of the spleen. There are also three comparable types: (1) rapid succumbing of the patient; (2) shock, recovery, more shock, signs of internal hæmorrhage; (3) delayed rupture.

The right lobe is involved five times more frequently than the left, and radiographic examination quite often shows fracture of any of the 9th to the 12th ribs of the right side or fractures of the right transverse processes of the first two lumbar vertebræ. If the local signs point to a right-sided lesion, there is no particular difficulty in differentiating between a ruptured liver and a ruptured spleen.

A youth of 17 was running to catch a bus, when he fell and hit his right side on the kerb. He did not lose consciousness, and he did not vomit. The pain in the right side of the lower part of the chest was excruciating. He was brought to hospital in an ambulance.

Rigidity and a dull note to percussion in the right hypochondrium made the diagnosis of rupture of the liver practically certain. Two hours later, in spite of a plasma infusion to combat shock, and morphine to relieve the pain, the half-hourly pulse-rate was rising.

Laparotomy revealed a cleft in the liver like a crevasse. It amounted to practically a split through the entire liver substance lateral to the gall-bladder.

Admittedly a deeply lacerated liver is a most formidable lesion carrying a high mortality, associated intra-abdominal lesions being even more common than those occurring with rupture of the spleen. Should the diagnosis of ruptured liver *per se* be rendered extremely probable, there are some who still believe in conservative treatment.[1] The patient is given a slow-drip blood transfusion in the hope that Nature will localize a perihepatic hæmatoma. Too often the outcome of this course is as follows: if the patient escapes death from hæmoperitoneum, he succumbs to bile peritonitis. Undoubtedly the *mortality following conservative treatment of rupture of the liver is* much higher than that following a well-timed operation.

REPAIR OF A RUPTURED LIVER

The optimum time for operation is within three hours of the injury. Should compatible blood not be available in time, plasma or dextran is administered pre-operatively and during the operation; autotransfusion can be undertaken; this is still a most valuable measure. Even if a ruptured liver is only suspected, have in readiness:—

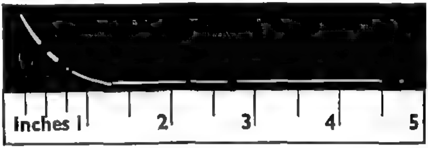

Fig. 476.—Post-mortem needle. Cutting edges have been rounded.

Special Equipment.—

1. The strongest catgut available. If there is nothing stronger than No. 2, use it doubled. See that it is soaked and made pliable, and the kinks are taken out of it before use. Ribbon catgut is most desirable.
2. Gelfoam[2] and/or oxycel[3] absorbable gauze have become almost a necessity.
3. If a special liver needle (*Fig.* 477) is in the instrument cupboard, of course have this put out.

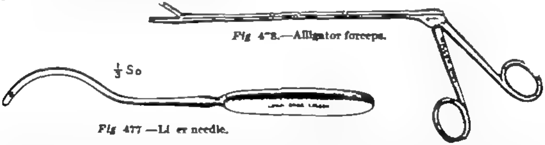

Fig. 478.—Alligator forceps.

Fig. 477.—Liver needle.

4. The largest round-bodied needles in the theatre. Often there are some very large curved needles about 3 in. (7.5 cm.) in length that gynæcologists employ. For suturing the liver Silvis employs a post-mortem needle, the cutting edges of which have been rounded by grinding on an emery wheel (*Fig.* 476). The grinding process decreases the temper, enabling the needle to be bent to any required curve. The eye is large enough to permit threading of ribbon catgut, the form of suture material that R. E. Silvis has found most satisfactory. It is well worth having two of these needles prepared against the day they will be required.
5. The longest malleable probe that has an eye in its extremity.
6. Alligator forceps (*Fig.* 478) provided they have fairly fine points.

[1] The conservative treatment of *penetrating* wounds of the liver often gives excellent results.
Sterispone (Sterilized Gelatin Sponge) is English equivalent, Allen & Hanburys Ltd., London, E.2.
Parke Davis & Co. Ltd., London.

The last may prove just what is needed. Contrary to what one imagines, alligator forceps cause less trauma to the liver than needles or probes that are passed threaded.

The Incision.—Considerable thought should be given as to the best incision to employ in a given case. For an average patient, probably the right paramedian splitting the rectus abdominis muscle for speed, is the best. If the patient has a wide subcostal angle a transverse incision gives good access to the spleen as well as to the liver but it does not permit full exploration of the abdomen. When the diagnosis is ? ruptured spleen, ? ruptured liver and the patient has a fairly narrow subcostal angle it is usually best to employ a mid line incision. Should the spleen be found to be ruptured, splenectomy can be carried out through this incision. If it is found that the liver is ruptured, in order to display the rent, it is highly probable that the latter incision will have to be extended. Should the rupture be accessible from the antero-inferior aspect the incision can be extended by a transverse cut to the right, dividing the rectus muscle. In cases where the rupture is on, or extends into the dome of the liver good exposures can be obtained by converting the abdominal incision into an abdomino-thoracic incision (see p. 309), which is well tolerated under positive-pressure anesthesia.

Fig. 479.—Compression of the free edge of the gastro-hepatic omentum, in order to control hæmorrhage from the liver (Hogarth Pringle's method).

Temporary Control of Hæmorrhage from the Liver.—The release of intra-abdominal pressure[1] by opening the peritoneum may cause a sudden, terrific hæmorrhage from a ruptured liver: hepatic blood is dark. By passing a forefinger into the epiploic foramen of Winslow and pinching the free edge of the gastrohepatic omentum between the finger and the thumb (*Fig.* 479) the portal vein and the hepatic artery are compressed, thereby almost completely controlling hæmorrhage from the liver. Such hæmorrhage as does then occur is derived from the hepatic veins. The compression can be maintained by an assistant until direct control of the hæmorrhage has been effected but the pressure should be released for about a minute every ten minutes, or viability of the liver cells is liable to be imperilled.

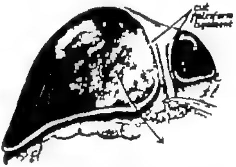

Fig. 480.—Traction on the round ligament may facilitate exposure of the laceration, which is more often on the anterosuperior surface of the liver.

Another cardinal fact is, if a ruptured liver is held in such a way as to bring the lacerated surfaces even slightly into apposition, serious bleeding ceases. This is the key to ideal treatment: even one deep suture properly placed, may be all that is required to aid Nature to cement the split.

Mobilizing the Liver.—After the round ligament of the liver is divided between hæmostats and the falciform ligament is divided with scissors, a certain amount of rotation of the liver becomes possible. By traction on the round ligament in a downward direction (*Fig.* 480), more of the convex surface can be brought into view. By the manœuvre illustrated in *Fig.* 481 a good deal of the postero-inferior aspect is rendered more accessible.

[1] What is more dangerous is that as soon as the anesthetist has administered a muscular relaxant the bleeding may become greatly increased, therefore it is unwise to inject one of these substances in cases where a ruptured liver is suspected until the abdomen has been opened.

Excision of Devitalized Tissue.—Many ruptures are clean-cut, and do not require excision of tissue. Pulped liver is impossible to suture: detached fragments must be removed, and lacerated portions of doubtful viability, particularly pale semi-detached pieces, must be resected. Failure to débride non-viable substance favours infection and increases the liability to secondary hæmorrhage, a combination of which is liable to culminate in the hepatorenal syndrome—a harbinger of death.

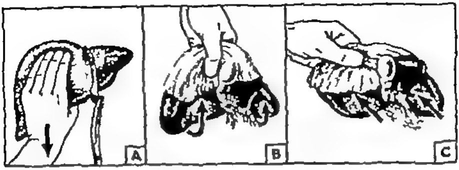

Fig. 481.—Method of enhancing accessibility to the postero-inferior surface of the liver.

G. B. Sanders' Case.—

One-third of the right lobe was partially detached, rendering its viability extremely doubtful. This was amputated. The raw surface of the liver was covered with several layers of oxycel, pressure being applied after each application, until the absorbable gauze became adherent. The hæmorrhage was staunched, and the patient recovered.

Ligation of Spurting Vessels.—Spurting vessels in the liver substance can be picked up delicately with hæmostats and ligated; the trouble is that many of them lie so deeply in the cleft that they cannot be reached without inflicting further damage to the liver. Diathermy coagulation here and there to a bleeding portal tributary is warranted, but diathermy coagulation on a large scale is hardly justifiable, for it causes too much liver necrosis.

Suturing the Tear.—Having obtained the best access possible to the rent, should it be not more than 5 in. (12.5 cm.) deep, take a long piece of catgut mounted on the largest curved round bodied needle available. After instructing the assistant how to compress the free edge of the gastro-hepatic omentum, pass a finger or fingers of the left hand into the rent. Insert the needle through sound liver substance quite 1½ in. (3.7 cm.) from the torn edge as deeply into the crevice as possible. Bring out the needle here. Reinsert it on the other side of the bottom of the crevice and bring it out on to the surface at least 1½ in. (3.7 cm.) away from the edge of the laceration.

When the laceration is deeper than about 5 in. (12.5 cm.), there is no needle long enough to carry out the work efficiently. A probe can be used, but what is better—is a pair of alligator forceps. It is possible with these to insert the necessary suture exactly where it is required (*Fig.* 482) and very expeditiously. Carefully and slowly tighten the suture and tie one-half of a knot. This will bring the edges together and the bleeding will practically cease. Gradually tighten the first half of the knot, being careful not to jerk it. It will be found to hold quite well. Hand the free ends of the catgut to the assistant and instruct him to hold them taut.

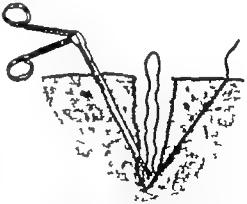

Fig. 482.—Using alligator forceps to pass the cardinal stitch that draws together an extensive deep tear.

With a ligature of cotton on a needle, undersew the half knot and tie the cotton tightly. This will lock the half knot when the catgut knot can be completed with impunity. It may well be that this solitary stitch will be all that is necessary; at any rate it is the principal stitch. Other less deep stitches can be placed as necessary. When absorbable gauze is available this should be placed under the suture before tying the knot. More of it can be used under other sutures. The subsidiary stitches can take the form of any

of the accepted methods of suturing the liver For instance a piece of costal cartilage can be used as a buffer (*Fig* 483) A cutting needle will easily penetrate this cartilage

When time and excellent exposure permit, probably the ideal method of repairing a rent in the liver is to pass four or six deep sutures of ribbon catgut. These are

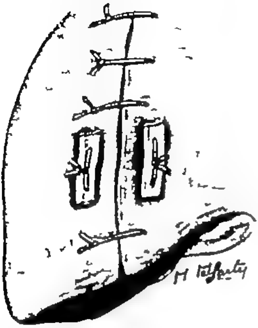

Fig 483.—A split piece f costal cartilage can be used as a buffer

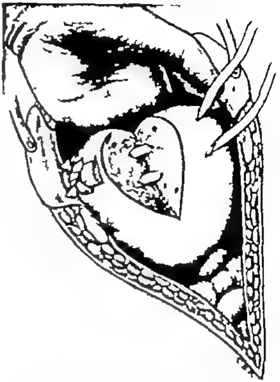

Fig 484—Coapting the surfaces of traumatic cleft of the liver with ribbon catgut tied over oxycel as mattress sutures. Abdomino-thoracic approach. (*After Decline and Barnett*)

tied in pairs over pieces of oxycel (*Fig* 484). The everted lips of the laceration are covered with oxycel, kept in place by a sufficient number of sutures placed more superficially

When (after débridement) there is Loss of Substance.—The laceration should be packed with strips of oxycel or a suitably-shaped piece of gelfoam, preferably soaked in thrombin topical. Two or three superficial sutures should be passed and tied loosely to keep the oxycel or gelfoam in place (*Fig* 485)

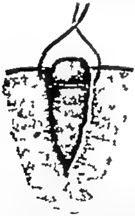

Fig. 485.—Absorbable gauze plugging a laceration with loss of substance

When this method has been used for a laceration in a portion of the liver in contact with the diaphragm, suturing the liver capsule to the diaphragm (*Fig* 486) will prevent the suction effect of the diaphragm on the liver

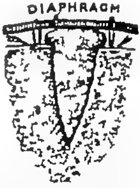

Fig 486.—Absorbable gauze plugging a laceration with loss of substance Li er c psule sut red to the diaphragm.

The use of large quantities of gelfoam or oxycel (as a pack), although effective in controlling hæmorrhage is to be discouraged if it can be avoided. Only a certain thickness of these substances can be absorbed readily the remainder if it becomes even mildly infected, gives rise to an abscess, especially if débridement has not been, or owing to inaccessibility can not be carried out.

Summarizing Whenever possible the aim should be to l the lacerated surfaces of the liver together not to prise them apart w ions

By adoption of the above principles the mort been reduced from 65 per cent in 1930 to 10 per cent (W E. Mil

Drainage.—Because of oozing leakage of bile and extrusion of small fragments of autolysed liver drainage of the perihepatic tissues in the vicinity of the rupture is highly desirable. It is important that the drainage tube should not be disturbed until the fifth day and that the drain should be removed rather slowly at the rate of about 1 in (2 5 cm.) a day

Packing a Deep Rent with Gauze has been practised since the early days of abdominal surgery The results have been poor often the patient has given promise of recovery only to succumb (usually after the packing was removed) to secondary hæmorrhage or the hepatorenal syndrome, and this method fell into disrepute. While packing *should be resorted to only when more refined methods are considered impracticable* with antibiotic therapy the outlook has improved In the following successful case reported from the Cook County Hospital, Chicago, the very long time the packing was left in the liver should be noted particularly Doubtless this is the secret of success because it prevents bile peritonitis, which has so often proved fatal in the past.

J M Green s Case —

A man aged 32, was admitted after a quantity of steel tubing had fallen on his back one hour previously There was tenderness and some rigidity in the upper right quadrant and a tentative diagnosis of injury to the liver without intra-abdominal hæmorrhage was made, and conservative treatment advised. Radiography was negative. A blood-saline-dextrose drip was given. Forty eight hours after the injury there was severe abdominal pain, rigidity distension, and tenderness over the whole abdomen. Shortly afterwards the abdomen was opened through a vertical right

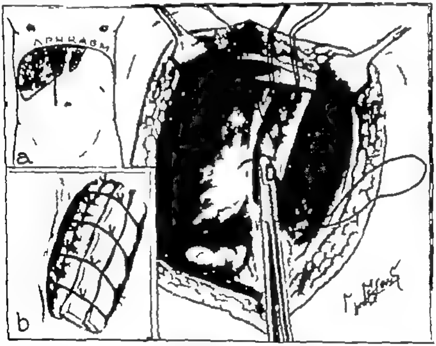

Fig. 437 —Repair of the li er after amputation of its left lobe ; (B) sutures lie over gelfoam (*After E W Wechel.*)

rectus incision, and the peritoneal cavity contained approximately 2000 ml. of fresh blood containing clots. There was a tear of the right lobe of the liver just to the left of the gall-bladder The liver was split across except for 3 in. (7 5 cm.) posteriorly where it was held by the hepatic capsule The two halves were separated by a gap of 3 in. The liver was situated high under the ribs, and it was decided to pack the rent with gauze. About 19 ft. (5-6 m.) of gauze was packed into the tear which controlled all bleeding The abdominal wall was closed in layers and the gauze was left protruding from the upper end of the incision. During the operation the patient received 500 ml. of whole blood and 1000 ml. of saline solution. Following the operation, he received penicillin and streptomycin daily

The post-operative course was very stormy For eight days the patient was semi-comatose and suffered from pulmonary œdema, as well as œdema of the ankles and feet, which abated after intravenous fluids were decreased. For the pneumonia which followed, in addition to other antibiotics, 500 mg of aureomycin was administered daily Continuous gastric aspiration was discontinued on the tenth day when fluids by mouth were started. On the thirteenth post-operative day 5 ft (1 5 m.) of packing was removed by constant twisting and gentle traction under thiopentone

anæsthesia. On the fifteenth day an additional 6 ft. (1·8 m.) was removed. The remainder was removed on the eighteenth day. Bile continued to drain from the wound for 103 days, but the patient recovered completely.

It might be added that removal of the packing under anæsthesia should be conducted with blood transfusion in progress. If undue bleeding occurs, it must be controlled by repacking with fresh gauze.

Rupture of the Left Lobe *of the liver is comparatively infrequent.* When the tear is extensive the viability of the lobe becomes doubtful. In such a case it is best to complete the amputation of the lobe and after ligating spurting vessels to pass sutures through the whole liver 1 in. (2·5 cm.) from the lacerated surface. The raw area is covered with a sheet of gelfoam and the sutures are tied over it *Fig.* 487.

E. H. Werbel's Case.—

In a case of almost complete rupture of the left lobe Werbel completed the amputation. Spurting blood-vessels on the cut liver surface were ligated. Sutures were passed through the entire thickness about 1 in. (2·5 cm.) from the cut surface. They were tied mattress fashion, in pairs. The ends were left long, and tied over gelfoam.

Post-operative Care (All Cases).—The patient must be maintained on full doses of antibiotics for at least ten days, with adequate blood, fluid and electrolytic replacement.

Fig. 488.—Operative findings in Weeks's case of subcapsular rupture of the liver.

Delayed Rupture.—Like certain cases of rupture of the spleen, symptoms of severe *intraperitoneal hæmorrhage* from a ruptured liver are sometimes delayed for hours, or even days. From time to time a subcapsular hæmatoma is a cause of diagnostic perplexity and, if it can be evacuated before it bursts, so much the better.

A. Weeks's Case.—

A cowboy was kicked by a horse, and four lower ribs on the right side were broken. For two days he passed a little blood in the urine.

On admission to hospital fourteen days later a large swelling was found in the right side of the abdomen. By cystoscopy etc. it was proved that the right kidney was normal. An incision was made beneath the right costal margin, and the swelling was found to be an enormously enlarged liver quite free from adhesions (*Fig.* 488). A trocar with a tube attached was inserted, and straw-coloured fluid poured out. As the patient's pulse-rate rose to 140, the tube was clamped, the trocar left in place, and the wound was closed around the trocar. At intervals 1¾ pints (1000 ml.) drained away over a period of three days. The patient made a good recovery.

Spontaneous Rupture.—Spontaneous rupture of the liver is very infrequent. *Most of the patients have been pregnant at the time of rupture.*

H. Link's Case.—

Mrs. A., aged 42, sixteen weeks pregnant, was admitted as an acute abdominal case. Twelve hours previously she experienced sudden violent abdominal pain while peeling potatoes. Laparotomy showed that the peritoneal cavity was full of blood. No cause for the hæmorrhage could be found in the pelvis. The incision was extended upwards, and the spleen was found to be normal. Following the clots, the hæmorrhage was found to be pouring out of the foramen of Winslow. The gastro-hepatic omentum was incised, and after the blood and blood-clot had been removed from *the lesser sac, a rupture 2 in. (5 cm.) in length was located in the caudal lobe.* The rupture was blocked with a piece of the right rectus muscle sutured into place. Blood transfusion was given, and the patient recovered.

Other cases have been reported where the rupture was thought to be due to the violent contractions of the diaphragm and the abdominal muscles during labour. Eclamptic lesions constitute a primary cause of subcapsular hæmorrhage and capsular rupture. The mortality of spontaneous rupture of the liver is very high; five reported cases have recovered following surgical intervention (D. Kramish).

Massive Intestinal Hæmorrhage following Traumatic Rupture of the Liver (Traumatic Hæmobilia) is a rare complication of central rupture of the liver. *There are periodic attacks of bleeding due to an accumulation within the liver of blood and bile.* When the intrahepatic pressure becomes sufficiently raised, the contents of the cavity are expelled through the bile ducts. The mortality is 50 per cent. The hæmorrhage must be controlled by *open operation, with packing and drainage of the interior of the cavity.*

Closed Traumatic Rupture of the Diaphragm.—*See* p. 431.

LACERATION OF THE MESENTERY

Hæmorrhage from the mesentery may be brisk, but it is readily controlled (*Fig* 480). Should a tear in the mesentery be parallel to the gut (*Fig* 400) the blood supply to the intestine in the immediate vicinity of the tear is endangered When the tear is more than two inches in length resection and anastomosis should be carried out Small tears may be closed, but always wait a few moments after the closure has been effected before returning the coil of intestine Even a slight change in colour in the intestinal wall in the vicinity of the injury as

Fig. 480 —Compression of the superior mesenteric artery in a case of laceration of the mesentery

compared with the remainder of the intestine indicates an impaired blood-supply and the advisability of resection should be reconsidered. Longitudinal tears (*Fig* 491) can be closed safely.

For closing mesenteric lacerations the following practice is a good one. Bleeding points are caught, care being taken to include as little tissue as possible in the hæmostats. A ligature

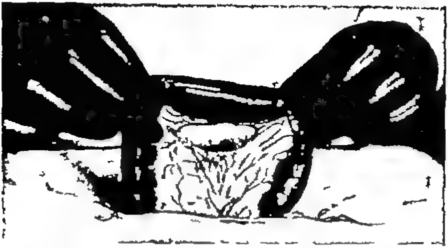

Fig 490.—Laceration of the mesentery. A tear more than 2 in. (5 cm.) in length parallel to the gut. *Resection imperative.*

is then thrown about two hæmostats situated on opposite sides of the laceration. Thus the ligatures not only ensure hæmostasis, but bring together the edges of the mesentery (*Fig* 492). This technique has the advantage over stitching in that blood vessels are not pricked.

Hæmatoma of the Mesentery.—A large hæmatoma may strangulate the blood vessels supplying the gut. In deciding whether it is safe to leave a hæmatoma entirely alone, one should first examine both sides of the mesentery. If the hæmatoma is in evidence on both sides, it should not be passed by lightly. When the overlying gut appears healthy, aspiration of the blood in the hæmatoma may be attempted. If after aspiration, the hæmatoma re-forms quickly, it is a sign that a vessel requires ligature, and the hæmatoma must be opened. After hæmostasis has been secured, the same precautions of deciding upon the viability of the intestine as were detailed above should be taken.

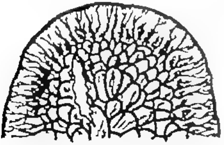

Fig 491.—Longitudinal laceration of the mesentery. Such a laceration can usually be closed safely.

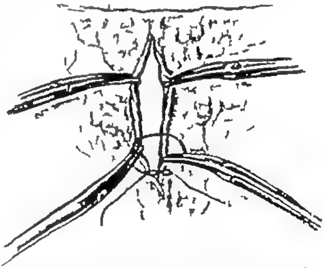

Fig 492.—Coapting the edges of the mesentery by ligatures thrown about hæmostats situated on opposite sides of the cut surfaces.

TRAUMATIC RUPTURE OF A MESENTERIC CYST

S. S., aged 5½, was pushed over in a playground at school, and immediately cried out with pains in the stomach. Four hours later, when admitted into hospital, the child was obviously shocked. On examining the abdomen, rigidity was found and the percussion note was dull.

During the two hours he was under observation the pulse rose from 108 to 130 A diagnosis of ruptured spleen was made

On opening the abdomen, fluid like curdled milk ran out in large quantities. This was traced to an opening near the duodenojejunal flexure I was about to suture up the ragged hole, believing that the duodenojejunal flexure had been torn, but the absence of bile in the fluid caused me to make a more thorough examination. It was soon clear that a mesenteric cyst had ruptured. The third and fourth parts of the duodenum and the neighbouring jejunum had been pushed upwards by the cyst wall. A tube was passed through the hole in the cyst and the cyst wall closed about the tube. The general peritoneal cavity was drained. The abdomen became very distended on the second day but the bowels moved freely After the fourth day recovery was uneventful.

RUPTURE OF THE SMALL INTESTINE

Early diagnosis is of great importance. If operation is delayed more than six hours, the patient s chance of recovery is greatly decreased If twelve or more hours have elapsed between the accident and operation, the prognosis is bad If operation is delayed twenty four hours or more, the result is usually fatal. The small intestine is ruptured ten times more often than the large.

When a patient has been struck upon the abdomen, and tenderness on pressure can be evoked, even in the absence of all other signs, if the tenderness persists for four hours, the

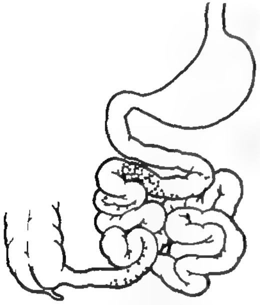

Fig 403.—The sites of traumatic rupture of the small gut from massed statistics. (*Veal and Barnes.*)

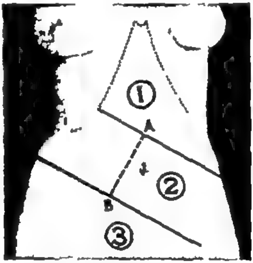

Fig 404 —Monk method of intestinal localisation. A–B Line of mesenteric root. Parallel lines are erected t the extremity of this line dividing the abdomen into three equal parts. The upper middle, and lower compartments here indicated contain, in most cases, the upper middle and lower thirds of the small intestine respectively

decision not to operate is many times more dangerous than to explore. In assessing the diagnosis, Schrire draws attention to the pitfall of the presence of an unsuspected lesion of the spinal cord. There may be most excruciating abdominal pain from such a lesion.

In 19 consecutive cases of rupture of the intestine Jacobson and Carter found the duodenum ruptured in 3, the jejunum in 7 and the ileum in 9 It is evident that the relatively fixed first and last 18 in. (45 cm.) of the small intestine are the most frequent sites for traumatic rupture (*Fig* 403)

Local tenderness is often the key to the site of the rupture (*Fig* 404). Attention is drawn to the fact that in rupture of the small intestine, at any rate during the first six hours following the accident in more than 90 per cent of cases there is no radiographic evidence of free subphrenic gas in the peritoneal cavity

Laparotomy.—The abdomen should be entered by a long paramedian incision. On opening the peritoneum, purulent, faecal, or bile-stained fluid may be found. It should be noted however that in early cases, especially when the rupture is situated in the jejunum, there is often only a little blood-stained fluid in the peritoneal cavity

In some cases the site of rupture with its mucous membrane pouting is evident at once. In others a cursory examination brings it to light on account of flakes of coagulated lymph in the vicinity and the fact that the site of the rupture is always surrounded by oedema. When a rupture is found at this, or at a later stage of the examination, a light clamp is applied to that coil, which is then wrapped in an abdominal pack and set aside until the presence or absence of similar lesions is confirmed or excluded. Rupture is most frequent near the antimesenteric border of the intestine.

Fig 495.—The whole of the intestine is examined systematically. A damaged segment is left outside wrapped in an abdominal pack; undamaged intestine is returned.

Ten per cent of intestinal ruptures are multiple; therefore do not be satisfied after finding one rent, but examine the whole course of the gut.

With an adequate incision, and the relaxation afforded by modern anaesthesia, it is an excellent practice to bring the whole of the small intestine on to the surface of the abdomen, and there to cover it with hot, moist towels, or place it in a Lahey's bag (*see Fig* 550, p. 417). This permits a view of the fixed portion of the colon, the paracolic gutters, and the retroperitoneal regions, but its main objective is to facilitate examination of the whole of the small intestine and its mesentery. Commence by examining the duodenum and the duodenojejunal flexure. If this is negative undertake a survey of the whole of the small intestine by running it through the fingers as it is held up (*Fig* 495) and then returning each coil to the abdomen. In this way not only the small intestine but also its mesentery can be scrutinized rapidly from the duodenojejunal flexure to the ileocaecal junction.

A rupture should be closed with a double layer of sutures. For the first layer catgut on an eyeless needle is the most suitable material, but the catgut should have been soaked in warm saline solution when it first comes out of the glass container it is very wiry. The second layer is of interrupted thread.

A small puncture is closed by a purse-string suture. Before attempting to close a larger rent, in order that the gut may be steadied and slightly stretched, pass a stay suture on either side of the rupture in a transverse direction. Leakage of intestinal contents is arrested by placing an intestinal clamp on the proximal side of the rupture. This, however, is seldom called for, for the pouting mucous membrane prevents much outpouring. Always remember to sew up a perforation of moderate size (½–1 in. (1.25–2.5 cm.)) in the transverse axis of the gut to prevent undue narrowing of the lumen (*Fig* 496). However, if it is found, after sewing up a more extensive tear, that some narrowing of the gut has occurred, this need not be a source of anxiety, for the contents of the small gut are fluid and their passage is

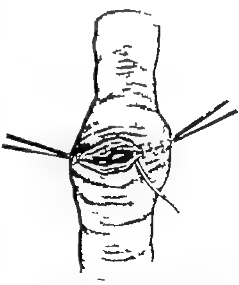

Fig 496.—Repair of a large wound of the intestine. The gut should be sewn up transversely to prevent narrowing of the lumen. For small puncture wounds a purse-string is used.

unaffected by a certain amount of constriction. After closing the perforation the suture line can be reinforced with a free omental graft which also helps to prevent adhesions to the suture line and possible intestinal obstruction.

The mortality is increased greatly by resection, which should be carried out only if the mesentery with its all important blood-supply is so damaged as to imperil the viability of the gut or when there are several large perforations within a short distance from one another.

In the event of a rupture being too long to close transversely Poth and Martin's ingenious method of repair (*Fig.* 407) can be employed safely. The rent in the intestine

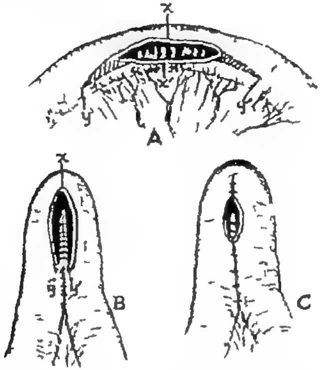

Fig. 407.—A, The defect may be enlarged to obtain a sufficiently long stoma; B, Showing the two posterior rows of sutures in place. The intestine has been folded on itself around points xx'; C, Uncompleted anterior sutures. (*After Poth and Martin.*)

must be really long, and in some cases it may be necessary to enlarge the defect to provide a sufficiently large stoma.

A suprapubic drainage tube should only be omitted in very early cases, and rupture of the jejunum is less likely to contaminate the peritoneum grossly than rupture of the ileum. The after-treatment is that of peritonitis. It is most important to keep the gastric aspiration tube in place until peristaltic sounds are heard, to administer an adequate quantity of parenteral fluid, and to continue with antibiotic treatment for at least ten days.

Case 1.—Male, aged 41. Stated that twenty-seven hours previously, whilst groping about to find a match, he fell over a chair and caught his abdomen to the left of the navel on a fender. Immediately afterwards he was in great pain and crawled to bed, but had no sleep. Agonizing supra-umbilical pain continued all night, *but there was no vomiting*. He had passed urine twice since the accident.

On examination, pulse 84, temperature 98° F. (36.7° C.). The abdomen moved well on respiration. The skin was burnt with a poultice above the umbilicus. There was intense general rigidity. Shifting dullness could be elicited. The most tender spot was just to the left of the umbilicus. Per rectum there was tenderness in the rectovesical pouch. A diagnosis of ruptured intestine was made. Midline laparotomy. *Free fluid in the general* peritoneal cavity and much flocculent general peritonitis. The duodenum and duodenojejunal flexure were examined and found intact. The small intestine was then passed through the fingers. Three feet (90 cm.) from the duodenojejunal

flexure there was a tear 2 in. (5 cm.) long near the mesenteric border This was sewn with a double layer of catgut, and the suture line reinforced with omentum. The rest of the intestine was examined with a negative result. Suprapubic drainage

During convalescence the real cause of the accident came to light He had been kicked in the abdomen by his wife One year later he was seen in perfect health.

Case 2.—Male aged 40. Saw a policeman endeavouring to arrest a drunken student and went to the aid of the law with the result that he was kicked in the hypogastrium. Four hours later he was admitted to hospital.

On examination he was very considerably shocked. The temperature was 96 F (35.6 C), pulse 84 There was board-like rigidity and tenderness, most marked to the right of the umbilicus. A right paramedian incision was employed. On opening the peritoneum, fæcal fluid escaped. A perforation was found 1 ft (30 cm.) from the ileocæcal valve The tear was 1 in. (2.5 cm.) in length and was situated on the antimesenteric border The perforation was closed. Suprapubic drainage

For the next few days the patient was in a desperate condition, the abdomen distended and drum-like. Improvement set in on the seventh day and, with the exception of some suppuration in the lower abdominal wound, he made a good recovery

Case 3.—Male aged 39 Fell fifteen feet from a scaffold. An iron barrow which he was wheeling fell on top of him.

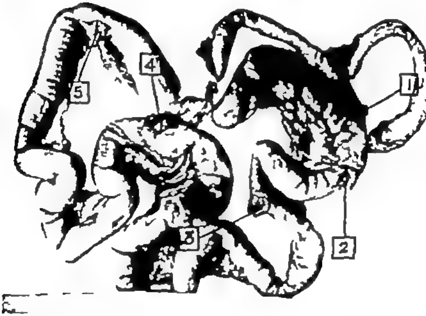

Fig 498.—A segment of jejunum 5 ft in length containing seven perforations (five of which are shown). Resection had to be undertaken because of a large wound of the mesentery Otherwise multiple wounds should be sutured.

On admission he was profoundly collapsed and blanched. Pulse 110; the temperature would not register *On examining the abdomen there was general board-like rigidity The maximum* tenderness was in the left hypochondrium. A catheter was passed, and the urine found to be normal. A diagnosis of ruptured spleen was made. By the time he reached the theatre half an hour later pallor was profound and the pulse barely perceptible

Midline upper laparotomy The peritoneal cavity was full of blood. The spleen and liver were *intact* *The hæmorrhage was found to be coming from a tear in the mesentery* through which the fist could be passed. The intestine itself in the immediate neighbourhood contained no less than seven perforations in 5 ft (1.5 m.) (*Fig* 498). The segment of jejunum containing the ruptures was resected, for the hole in the mesentery had, to a large extent cut off its blood-supply End-to-end anastomosis was performed. At this stage the patient stopped breathing and death appeared *imminent* *The abdomen was closed by through-and-through* sutures as quickly as possible and as this was being done occasional sighing respirations occurred. The head of the table was tilted downwards, and intravenous infusion was given, as no matched blood was available

He was returned to bed, and six hours later had fully regained consciousness and gave some hope of recovery During the night his condition became grave and he died. The post-mortem *examination showed a tear 1 in. (2.5 cm.) in length in the mesentery* 4 in. (10 cm.) from the ileocæcal valve The renewed hæmorrhage which had occurred from this lesion probably determined the fatal issue This case is quoted to emphasize the necessity of examining every inch of the small intestine

THE ASSOCIATION OF INGUINAL HERNIA WITH TRAUMATIC RUPTURE OF THE INTESTINE

Ian Aird has drawn attention to a very important association between inguinal hernia and traumatic rupture of the intestine

Late one evening a ship's engineer aged 36, while returning to his ship slipped and knocked his abdomen. Soon afterwards he felt sudden severe pain over the symphysis pubis where the pad of a truss only partially controlled a long-standing right inguinal hernia. This pain increased, and rose gradually higher in the abdomen. Vomiting occurred and was repeated. When seen four hours later the patient persisted in blaming his hernia for the attack of pain. It was obvious however that early general peritonitis was present and laparotomy was performed. A large quantity of turbid fluid was evacuated from the peritoneal cavity The peritoneum was everywhere congested, and numerous petechial hæmorrhages were present. The lower ileum was considerably dilated and a circular perforation was found, 4 mm. in diameter in the antimesenteric border of the bowel a few inches above the ileocæcal valve. The perforation was punched-out and there was no pouting of the mucosa. The perforation was closed and a temporary ileostomy performed above the closure. The patient was discharged three weeks later after an uneventful recovery

It is well known that rupture of the intestine may complicate ill-advised attempts at forcible taxis. Even reduction of a hernia oft-reduced by the patient himself can prove disastrous. An elderly man, reducing his own inguinal hernia in the erect position in the lavatory of a café ruptured his ileum (J P Cogley). Less common is the variety of rupture of the bowel occurring in a patient with an inguinal hernia after comparatively slight abdominal violence or sudden muscular strain. No case has yet been recorded of the condition occurring in a woman. All the reported cases, save one have been confined to some part of the small intestine

Fig. 400 —Explaining how remote violence can cause rupture of a loop of intestine in an inguinal hernia.

Summarizing: A loop of intestine lying within an inguinal hernial sac can be injured by *direct force* applied to the hernia. Rupture of the intestine may also be caused by violence to the abdominal wall owing to the transmission *of indirect force* to a loop of intestine within an inguinal hernia (*Fig* 400) If the signs of diffuse peritonitis present, *laparotomy* and *not exploration of the hernia, must be performed.* A paramedian incision on the side of the hernia will allow herniotomy from within should the patient's condition permit.

RUPTURE OF THE DUODENUM

Nine per cent of closed rupture of the intestinal tract are of the duodenum. The rupture may be: (1) Intraperitoneal (2) Extraperitoneal (3) Both intra and extraperitoneal

Intraperitoneal Rupture produces symptoms and signs similar to those of rupture of the intestine. Possible distinguishing features are that the pain is localized mainly to the epigastrium, and the serum-amylase is usually somewhat elevated, but it is not high (1000 Somogyi units) unless there is a concomitant rupture of the pancreas.

Extraperitoneal Rupture.—The clinical features are liable to be misleading. After the initial shock has passed off there is often an interval of comparative freedom of serious symptoms. Then, usually following a meal or even a drink sudden pain, often situated in the lower thoracic and upper lumbar region posteriorly commences, and repeated vomiting frequently occurs. Pain in the testicles, due to extraperitoneal irritation of their nerve-supply is sometimes present. When the diagnosis of retroperitoneal rupture of the duodenum is missed and operation is not performed, or when a retroperitoneal rupture is overlooked at laparotomy extreme toxæmia supervenes. Should the patient survive signs simulating those of a perinephric abscess develop. Incision of the abscess is followed by a duodenal fistula.

Radiography—*A plain radiograph not infrequently* shows the presence of small bubbles of air in the region of the right kidney and sometimes the margin of the right psoas muscle is outlined by the gas shadow In a few cases leakage into the retroperitoneal tissues has been demonstrated radiologically after the ingestion of lipiodol or a little thin

barium mixture but this method should only be employed when the symptoms are mild. Lateral or oblique films are particularly valuable.

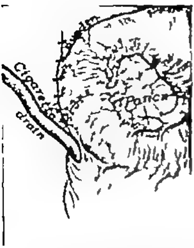

Fig. 500.—Intraperitoneal rupture of the second part of the duodenum with a retroduodenal extension. Suture completed, showing site of drainage tube (*After J. E. Stiler*.)

Pre-operative Treatment.—For intense pain, pethidine (demerol) is advised. The rationale in the use of this drug is based upon the fact that its atropine-like action diminishes gastric secretion. The stomach should be emptied and kept empty through a gastric aspiration tube. Water and electrolyte balance must be maintained intravenously. Antibiotic treatment is commenced as early as possible.

Laparotomy undertaken early greatly enhances the prognosis, but even with the benefits of antibiotics and blood transfusion, the total mortality is at least 30 per cent. A right paramedian incision gives satisfactory access. If a midline incision has been employed, and the first or second parts of the duodenum are involved, the exposure is liable to be inadequate, and a transverse cut to the right becomes necessary. Should the pre-operative diagnosis be tolerably certain, a transverse incision through the right rectus gives splendid access.

An intraperitoneal rupture can be demonstrated without much difficulty. Division of the gastrocolic omentum may be required to expose a tear in the distal half of the duodenum. One must be watchful lest the rupture extends extraperitoneally, and to this end, when a tear extends to the peritoneal reflexion, the interior should be explored with the little finger. An intraperitoneal rupture is closed in two layers, the outer being mattress sutures of linen thread (*Fig.* 500) reinforced by a patch of omentum. All extravasated material is removed from the operation area with a sucker and swabs. In cases of only a few hours' duration, provided the pancreas appears quite undamaged, drainage is unnecessary; otherwise Rutherford Morison's pouch should be drained through a stab incision. If, as is often the case, there is soiling of the general peritoneal cavity, suprapubic drainage is carried out also.

Fig. 501.—Mobilizing the greater part of the first part, the second part, and the inferior duodenal flexure. By grasping the right border of the second part with Babcock's forceps, and further gauze dissection, the posterior wall is displayed.

Retroperitoneal rupture has been overlooked at laparotomy on a number of occasions, for it is not readily seen. Frequently it is only diagnosed by a hæmatoma at the base of the mesocolon. In other early cases inspection will show that the duodenum in the vicinity of the rupture is œdematous, and the surrounding retroperitoneal tissues are bile-stained or the seat of extravasation of bloody fluid. In many cases the rupture can be palpated through the anterior duodenal wall. The rupture is often in the first, or particularly in the second, part of the duodenum. Always in the latter and usually in the former situation the lesion can be displayed by:—

Mobilizing the Duodenum.—The posterior parietal peritoneum is incised along the right lateral border of the duodenum. The incision is a generous one. By gauze dissection in the retroperitoneal tissues directed towards the middle line, the attachment of the ascending colon is freed, allowing this portion of the bowel to be packed away from the field of operation, thus exposing the greater part of the first part and all the second part of the duodenum (*Fig.* 501). Further dissection behind the duodenum permits good exposure of the posterior wall of the parts in

question This manœuvre allows closure of the rent in the usual manner The retroperitoneal space must always be drained with a soft drainage tube or a roll of corrugated rubber

C. A Salisbury opened the abdomen of a man aged 29 seven hours after he had been struck in the left upper quadrant. There was some blood-stained fluid in the peritoneal cavity but no evidence of peritonitis. The peritoneum over the second part of the duodenum was œdematous and elevated to the size of a large orange The second part of the duodenum was mobilized and after the bile-stained fluid had been swabbed away the second part of the duodenum was found to be almost completely divided. The edges of the tear were trimmed and united by interrupted stitches in two layers. Drainage was instituted and the patient made a good recovery

In a case described by Estes et al. a peculiar grey-black hæmatoma was found in the right paracolic gutter and retroperitoneal crepitation could be elicited. Exposure of the rupture in the second part of the duodenum was not obtained until the hæmatoma had been evacuated, the ascending colon and the duodenum had been mobilized and the gastrocolic omentum divided.

As a rule if the duodenum is mobilized thoroughly *retroperitoneal rupture of the first part of the duodenum* is quite accessible Should it be impossible to display clearly a rupture just distal to the pylorus, the method of procedure is as follows —

J A Simpson s Case.—

At laparotomy a large retroperitoneal hæmatoma overlying the head of the pancreas and extending into the base of the transverse mesocolon was apparent. After incising the peritoneal covering, the contents of the hæmatoma were evacuated, and on palpation a rent could be felt in the posterior wall of the first part of the duodenum. An attempt was made to visualize the lesion, but satisfactory exposure could not be obtained. The stomach was therefore divided through the pyloric antrum and the duodenum turned back. The tear was then displayed fully It was closed by two layers of linen thread sutures. The proximal end of the duodenum was closed and invaginated, and the distal cut end of the stomach was brought through the mesocolon and an end-to-side anastomosis made between it and the jejunum. Drainage of the retroperitoneal tissues was carried out by passing a tube through a separate stab incision.

Retroperitoneal Rupture of the Third Part of the Duodenum.—Should the rupture extend far into the third part of the duodenum it cannot be displayed adequately by mobilizing the duodenum. After the superior mesenteric vessels have been retracted to the left, the anterior wall of the duodenum is incised, thereby giving access to its posterior wall (*Fig* 502)

Fig 502.—Repairing a retroperitoneal tear in the third part of the duodenum. (*After R Russell Best*)

Rupture of the Duodenojejunal Flexure.—As a rule it is not a difficult matter to trim the ends and perform end to-end anastomosis Sometimes, when the intestine is torn across very close to the (retroperitoneal) duodenum, the proximal end retracts. However it is usually possible to catch the edges of the proximal end blindly in toothed forceps, and gently but firmly withdraw them from the retroperitoneal tissues sufficiently to be enabled to make an end to-end anastomosis. This must be done at all cost, for it is the only method likely to succeed. Avoid closing the proximal end and performing gastrojejunostomy as it will only lead to a life of invalidism from food passing into the duodenum, from which there is no escape except by regurgitation into the stomach

RUPTURE OF THE LARGE INTESTINE

For obvious reasons, rupture of the large intestine is very lethal. Fortunately it is comparatively rare. Of 231 cases of traumatic rupture of the alimentary canal without external wound collected by Sir James Berry only 13 were of the large intestine

There are few intra-abdominal catastrophes where the time factor is more important than rupture of the large intestine. When operation can be undertaken within three hours of the accident, the outcome is often successful, particularly since the introduction of antibiotic therapy which should be instituted as soon as possible

Rupture of the large intestine may be intra or extraperitoneal.

Radiography is especially helpful in the diagnosis of both these lesions, for gas escapes from a rupture of the large intestine at a very early stage, and with considerable regularity (*Fig* 303).

Bruising of the Large Intestine should always be regarded with circumspection, for undoubtedly it is a precursor of secondary perforation (delayed rupture) of this relatively thin-walled portion of the alimentary tract Several cases of delayed rupture of the cæcum and the colon occurring days after the accident have been reported. A small bruised area can be invaginated with a purse-string suture while a larger one is best cared for by covering it with omentum.

Fig 303. — Lateral radiograph showing both distended intestine and gross pneumoperitoneum, following delayed traumatic rupture of the cæcum. (*Gummer and Ranking*)

Juxtacolonic Hæmatomata should be evacuated by incising the peritoneum overlying the paracolic gutter vertically Since the retroperitoneal portion of the colonic wall may be bruised, the retroperitoneal tissues are drained through a posterolateral stab incision, because of the possibility of delayed rupture to devitalized bowel. Should crepitations be elicited over a retroperitoneal hæmatoma, after having attended to an intraperitoneal lesion, if such be present, the laparotomy wound should be closed and this infected collection of fluid evacuated and drained through a lateral extraperitoneal incision.

Intraperitoneal Rupture.—In some situations, if the patient is spare, a good method of dealing with the lesion, founded on military surgery is to exteriorize the damaged segment of intestine through a special incision. Time and circumstances permitting the Paul Mikulicz operation (*see Fig* 319 p. 300) is ideal nevertheless, just to exteriorize the segment if this can be done promptly will probably save the patient's life Some segments of the large intestine e.g., the transverse colon, lend themselves to a Paul Mikulicz procedure. With a little suitable dissection and freeing anatomical anchors, the hepatic and splenic flexures can be brought to the surface In the case of the ascending colon, and the pelvic colon particularly an incision through the peritoneum covering the posterior abdominal wall on the lateral aspect of the colon (*Fig* 304) allows retroperitoneal gauze dissection towards the middle line and by stripping up the peritoneum from the retroperitoneal tissues, a false mesentery is formed. This expedient frequently renders a ruptured segment of the large gut sufficiently mobile to be brought to the surface and there to be supported by one or two colostomy rods (*see* p. 447). When this can be done the perforation itself provides a convenient vent for fæcal matter and no other colostomy is required.

Fig. 304.—Site of incisions made through the peritoneum covering the posterior abdominal wall in order to mobilize fixed portions of the colon.

When the colon cannot be mobilized sufficiently (and such will be the case when the rupture is situated at the rectosigmoid junction or when the patient is obese) recourse must be made to suture (*Fig* 505).

It is inadvisable ever to rely on suture only even in early cases. (*a*) Drainage must be provided down to the suture line and the incision is closed about the tube (*b*) Colostomy should then be performed well above the injured segment, for instance, transverse colostomy and the colostomy opened forthwith If a lesion of the ascending colon has been sutured, caecostomy is performed. If the caecum is ruptured a de Pezzer catheter is introduced through the tear which is closed and embedded around the catheter

Summarizing Although exteriorization is sometimes the treatment of choice, particularly on the left side suture with proximal colostomy is frequently more advantageous, because the extensive mobilization necessary for exteriorization causes considerable shock, and in the obese it is liable to be impracticable.

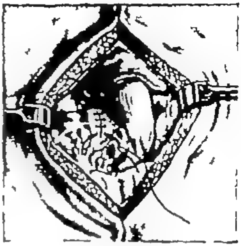

Fig 505.—Closing a rupture at the rectosigmoid junction
(*After Sir Cecil Wakeley*)

Retroperitoneal Rupture.—Initially there is an escape of flatus into the retroperitoneal tissues, but soon afterwards rapidly progressive crepitating cellulitis caused by gas-forming organisms, commences, and complicates the situation rendering retroperitoneal colonic rupture even more dangerous than the intraperitoneal variety After laparotomy to confirm or exclude other injuries, it is of paramount importance to close the laparotomy incision and to approach the retroperitoneal rupture through a lateral extraperitoneal incision. An attempt should be made to close the perforation but sometimes the stitches do not hold well. Meticulous closure need not be insisted upon, for if free drainage is provided and maintained, retroperitoneal lesions heal spontaneously A temporary colostomy in the anterior abdominal wall above the lesion should be provided.

COMPRESSED-AIR RUPTURE OF THE COLON

To those cases of traumatic rupture of the large intestine that accrue from the usual hazards of civil life must be added compressed-air rupture of the gut. This is nearly always the result of a damnable form of practical joke. A hose carrying air under considerable pressure is turned on near the victim's anus. The site of rupture is usually in the pelvic colon (*Fig* 506).

J C. Conline reported the following case from Ancoats Hospital, Manchester —

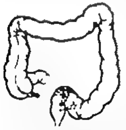

Fig. 506. — Location of perforation in collected cases of compressed-air rupture of the bowel.
(*After Brown and Dedinelli*)

An engineer's apprentice, aged 16½ was admitted complaining of difficulty in breathing and abdominal pain. He stated that about an hour previously while leaning over a balcony two of his fellow workers put the nozzle of a pipe conveying compressed air between his buttocks, and pressed the release button. Suddenly he felt "blown up" and could breathe only with difficulty He had not vomited. The patient was pale, but his lips were cyanosed he was dyspnoeic, with movement of the alæ nasi. Respirations were shallow and grunting The abdomen was greatly distended, tympanitic with generalized tenderness and an absence of peristaltic sounds. There was a reddish-blue mottling of the flanks extending on to the lateral abdominal walls. Nothing abnormal was felt per rectum, but withdrawal of the finger was followed by a profuse discharge of blood-stained fæcal-smelling fluid. The diagnosis of pneumatic compressed-air rupture was obvious. A Ryle's tube was passed, and the contents of the stomach evacuated.

Operation—Right lower laparotomy was performed, and a small opening made in the peritoneum. Air whistled out the abdomen collapsed like a pricked balloon, and the patient's breathing improved considerably There was no free fluid in, and no obvious fæcal contamination of, the peritoneal cavity The upper end of the pelvic colon was ruptured, and in the hole was a plug of solid fæces. The pelvic mesocolon

and retroperitoneal tissues were infiltrated with blood, and there was a little free blood in the rectovesical pouch. The pelvic colon and rectum showed tears in the serous and muscular coats on the antimesenteric border of the bowel. They started at the upper part of the rectum, where they were small and increased in size until the point of rupture was reached thereafter all the injured part was viable and active pulsation could be seen in the vessels supplying it. The hole in the pelvic colon was closed in two layers with No. 00 thread, and the tears in the serosal and muscular coats repaired with similar sutures. Transverse colostomy was performed at the end of the operation. The abdomen was closed around a sump drain inserted into the pelvis. One pint (570 ml.) of blood was given in the operating theatre A course of 500,000 unit of crystalline penicillin twice daily was given. During the first 24 postoperative hours 2 oz. (60 ml.) of blood-stained fluid was withdrawn from the sump drain, which was removed after 48 hours. Convalescence was uninterrupted.

A similar type of perforation of the colon has occurred during sigmoidoscopy In reported cases the patient has been under a general anæsthetic Sigmoidoscopy under a general anæsthetic is a dangerous procedure

RUPTURE OF THE PANCREAS

Traumatic rupture of the pancreas is rare and is not infrequently accompanied by damage to other abdominal organs, particularly the spleen duodenum and jejunum. For some hours after recovery from the initial shock, signs of serious intra-abdominal injury are often lacking then (owing to the extravasation of pancreatic ferments) epigastric pain and repeated vomiting set in. That the pancreas has been severely damaged can be diagnosed only by a serum-amylase estimation which, if raised considerably is good evidence that the pancreas (or the duodenum) has been ruptured. In the case of the pancreas, very soon after the accident the serum-amylase level becomes very high. At laparotomy the presence of fat necroses and a small quantity of blood should direct attention to the pancreas as the seat of the damage.

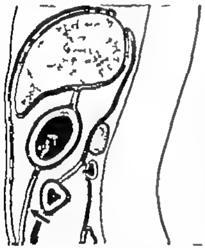

Fig 507 — Approach to the pancreas by detaching the greater omentum from the transverse colon

Approach to the Pancreas.—The organ can be displayed to the best advantage not through the gastrocolic omentum, as is usually described, but by detaching the greater omentum from the transverse colon (*Fig* 507) (R. Maingot).

Should the Pancreas be sutured?—If the tail of the pancreas is completely or nearly severed it should be removed, and it would seem advisable to cover the raw surface with a freed piece of omentum, and to retain it there with two sutures passed through the whole thickness of the pancreas. Whether suture of a deep laceration in the body or head of the pancreas (the body is the more usual site) should be undertaken is open to question. Burnett considers that suture of the friable pancreas only causes further pancreatic destruction. Certainly in some reported cases, when a deeply lacerated pancreas has been stitched putty-like sloughs of necrotic pancreatic tissue have been extruded through the drainage tract about the tenth day To compromise it is suggested that one stitch passed through the entire pancreas on either side and tied not tightly so as to prevent cutting out, can serve a dual purpose of arresting hemorrhage and bringing the severed ends of the duct of Wirsung into appodition. Drainage to the site of rupture must always be provided

Prevention of Burst Abdomen.—Burst abdomen is a common complication after pancreatic injuries.

To suture the abdominal wall with unabsorbable sutures, for instance stainless-steel wire is of definite prophylactic value, but other preventative measures (see p. 172) must be taken in addition.

Prevention of Skin Excoriation from Escaping Pancreatic Ferments.—Aluminium paste should be applied to the skin of the abdominal wall as a routine prophylactic measure

The Use of Drugs to Inhibit Pancreatic Secretion.—During the first ten post-operative days, drugs that diminish pancreatic secretion enhance the healing of the pancreas. Unfortunately they are almost useless unless the total fluid intake is limited to about 1500 ml daily. Care must be taken to prevent severe dehydration, and if untoward signs of dehydration develop more fluid must be given. The best drug for the purpose is propantheline bromide given by mouth in doses commencing at 15 mg daily working up to 60 mg daily by the fifth day and stopping the drug on the tenth day. If this drug is not available the subcutaneous administration of 0·4 ml of 1–1000 solution of epinephrine produces a marked diminution of the flow of pancreatic juice owing to the vasoconstrictor action of the drug causing a decreased volume of blood flow through the pancreas.

W. *Burnell's Case* —

As a result of a football accident a man aged 20 received a blow in the epigastrium. After visiting the Casualty Department where no serious signs or symptoms were found, he went home. Slight epigastric pain returned, and after a meal he vomited, and the pain became more severe. The pain and vomiting persisted during the night, until his admission to hospital the following morning. There was abdominal tenderness, more noticeable on the left side with slight rigidity on the left. Radiological examination showed some gaseous distension of two loops of small intestine in the mid-abdomen. The serum-amylase level was 4180 Somogyi units.

After drinking a cup of tea the symptoms returned, the pulse-rate rose to 86, and the temperature to 101·0 F (38 7 C.). At this time, about thirty hours after the injury laparotomy was performed through a left paramedian incision. There was a little blood in the left paracolic gutter and in the pelvis. There were a number of fat necroses in the mesentery of the jejunum. On opening the lesser sac the pancreas was found to be completely transected in the region of the portal vein and mesenteric vessels. The two parts of the pancreas were separated by a distance of 1–2 cm. After a soft-rubber tube had been passed down to the site of the rupture the abdomen was closed around the tube. No repair of the pancreas or its duct was attempted.

The post-operative treatment was directed towards keeping the pancreatic secretion to a minimum. Little or no fluid was allowed by mouth for the first 48 hours after operation, and only 1 5 litres of intravenous fluid was given during this period. In addition, propantheline bromide was given by mouth in doses rising from 15 mg to 60 mg daily for the first ten days. Morphine was not used to control the pain because of its tendency to cause spasm of the sphincter of Oddi pethidine was found to be effective, but was required in a dose of 300 mg daily for the first three days. On the fifth day a degree of peripheral circulatory failure became apparent and an intravenous infusion of dextran and 5 per cent glucose was given over the next 72 hours, by which time he was able to drink adequately and rehydration soon occurred. At the termination of the course of propantheline bromide, pancreatic fluid commenced to discharge from the drainage track, but the total daily loss was small. Skin digestion was prevented by aluminium paste. The fistula healed completely in thirty-three days.

Pseudo-pancreatic Cyst following an Injury to the Pancreas.—The development of a large collection of fluid in the lesser sac (pseudo-pancreatic cyst) following a pancreatic injury is a recognized clinical entity. The interval elapsing between the injury and the recognition of the cyst is usually between one and three weeks.

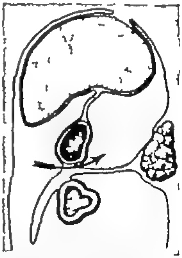

Fig 503—Pseudo-pancreatic cyst following injury of the pancreas. The lesser sac is drained by opening the peritoneum between the greater curvature of the stomach and transverse colon.

W K. aged 20 was admitted with abdominal pain and repeated vomiting. Fourteen days previously he had been jammed between a pillar and the shaft of a horse van. After the accident he walked home and called in a doctor. Since that time he had been in bed, with a dull pain in the upper abdomen, but vomiting was the chief complaint. He had vomited twelve times on the day of admission and eight times on the previous day. On examination the patient looked pale and ill. The pulse was 100 and the temperature 99 F (37 2° C.). There was a large tender swelling, dull to percussion, extending from beneath the left costal margin to the umbilicus. On opening the abdomen the stomach was found to be pushed forward by a tense cystic swelling in the lesser sac. There was a considerable amount of straw-coloured fluid in the general peritoneal cavity. After packing off the area so as to avoid soiling the general peritoneal cavity the lesser sac was opened *between the colon and the greater curvature of the stomach* (*Fig* 503). Pints of yellowish

opalescent fluid escaped, and as the cyst collapsed some flocculent curd like material was evacuated. A tube was passed into the lesser sac and the wound closed about the tube. The sinus took over six weeks to close finally. An examination of the fluid evacuated showed it to be sterile, but rich in pancreatic ferments.

Fig. 500.—Radiograph of lipiodol injection of the pancreatic fistula. (*Sir Geoffrey Keynes.*)

Jurasz's Operation.—In cases of pseudo-pancreatic cyst of several weeks' standing, or recurrent cases, Jurasz's operation is probably preferable. A large opening is made into the cyst through the posterior wall of the stomach by the transgastric route. To the edges of the opening a hæmostatic suture is applied. The contents of the cyst then drain into the stomach. The operation is said to be very successful; convalescence is greatly shortened thereby, and the complications of recurrence and fistula formation are obviated.

Pancreatic Fistula.—Should the duct of Wirsung be involved in the rupture, a pancreatic fistula is liable to follow drainage of the peripancreatic tissues. Sir Geoffrey Keynes's patient, aged 20, developed a copious fistula after his ruptured pancreas had been treated by drainage of the lesser sac. The fistula healed, and a pseudo-cyst formed. The cyst was drained, only to be followed by a recrudescence of the fistula (*Fig. 500*). By dissection the fistula was mobilized with difficulty. It was then implanted into a loop of jejunum, the anastomosis being made around a suitable piece of rubber tubing. After a stormy convalescence the patient recovered.

INJURY TO THE GALL-BLADDER AND BILE-DUCTS

On opening the abdomen, if *bile* is chiefly in evidence, examine: (1) The gall-bladder. (2) The duodenum. (3) The cystic duct. (4) The common bile-duct. (5) The hepatic ducts.

Moynihan's method of rotating the common bile-duct may be useful in searching for the point of rupture. The left hand is passed transversely above the stomach along the gastrohepatic omentum. When the hand is well placed, the fingers are flexed and the hand and wrist are directed towards the patient's left, with the result that the common duct is twisted up into the wound.

RUPTURE OF THE GALL-BLADDER

If the gall-bladder is found to be irreparably damaged, cholecystectomy will have to be performed, but there can be but few cases in which the edges of the tear cannot be approximated around a tube. In most cases the tear is a small one. If it is near the fundus, the hole can be used for cholecystostomy. If elsewhere, it should be sewn up and deliberate cholecystostomy performed. The peritoneal cavity should be drained.

Run-over accidents have accounted for most of the cases. The late W. Thelwall Thomas, of Liverpool, operated upon a boy who had been run over by a cart. On opening the abdomen, bile poured forth. The torn gall-bladder was stitched about a tube, and in addition the peritoneal cavity was drained. The boy recovered, and five years later I saw him when he presented himself on account of some vague abdominal pain.

A rupture of the gall-bladder in a healthy subject results in extravasation of normal bile which is sterile. If operation is undertaken reasonably early, the results are exceedingly good.

Serious symptoms are sometimes delayed.

Benson and Prust's Case.—

A boy, aged 5½ years, was admitted after having been knocked down by a motor car. There was a tyre mark over the right upper quadrant of the abdomen, and the right lower thorax, and multiple abrasions. The child showed gradual improvement until three days after admission, when he developed spasmodic pain in the right upper quadrant of increasing severity, accompanied by rigidity and tenderness. The attacks lasted for a few minutes, then disappeared for five to six hours.

Laparotomy disclosed small collections of bile among coils of small intestine plastered together with exudate. Examination of the gall-bladder revealed a perforation on its peritoneal surface at the junction of the lower and middle thirds. Cholecystostomy was performed through the dome of the gall-bladder. The perforation was sutured and drainage of the subhepatic pouch was carried out. Uninterrupted recovery.

TRAUMATIC RUPTURE OF THE BILE-DUCTS

This is less common than injury to the gall bladder and unless it is associated with other grave injuries, is not rapidly fatal. Often it is the gradual distension of the abdomen with fluid and perhaps jaundice, that call attention to the condition after several days. Aspiration of bile from the peritoneal cavity is pathognomonic of some part of the biliary tree having been torn.

Untreated pyrexia, loss of weight, increasing jaundice and toxæmia precede a fatal termination.

Rupture of the Cystic Duct.—Clearly the treatment indicated is to clamp and ligature the stump and to perform cholecystectomy

Partial Rupture of the Common Hepatic Duct and Its Branches.—In comparatively early cases, before the surrounding parts become œdematous and bile-sodden, it is possible to determine whether the rupture is complete or incomplete If incomplete, drainage of the vicinity (and drainage of the general peritoneal cavity if there is bile therein) will, in all probability result eventually in a restitution of the continuity of the duct. It is certainly well worth trying In the unlikely event of biliary fistula ensuing, after three months the fistula must be treated by further operation.

Complete Rupture of the Common Hepatic Duct, or One of Its Branches.—If simple drainage is carried out, a biliary fistula will result, the surgical treatment of which is extremely difficult If suture is undertaken it is doomed to failure—a stricture has developed in every reported case. The surgical rectification of a stricture of this duct is even more difficult than the dissection, and implantation of a biliary fistula. To circumvent these depressing sequelæ the operation devised by Milnes Walker has everything to recommend it —

A male, aged 2 years, was brought to hospital twelve days after an abdominal injury The patient was lethargic, slightly jaundiced, the abdomen was distended with fluid, and the stools were pale. Paracentesis revealed bile.

After careful and prolonged pre-operative preparation, a subcostal incision allowed escape of bile, and after separating adhesions, bile was found issuing from a minute orifice at the porta hepatis. A fine probe passed only 8 mm. up the sinus. Dissection amidst the œdematous bile-stained tissues was impracticable. A short length of polythene tubing was passed into the sinus and secured by a stitch passed through the margin of the orifice. The protruding tube was then implanted into a loop of jejunum, which was afterwards stitched to the tissues around the porta hepatis. Side-to-side anastomosis between the limbs of the loop was made, and the abdomen was closed with drainage. Recovery A year later the child was quite well.

Partial Rupture of the Common Bile-duct.—If the rupture is on the anterolateral aspect of the duct, it can be remedied by passing a T tube into the rent. Perhaps one stitch can be useful in approximating the severed ends (*Fig* 510) but as a rule this is unnecessary This tube should not be removed for at least fourteen days. Drainage to the site of rupture and of the general peritoneal cavity is also required. Stricture, which so often follows operative accidents to the common duct, does not occur after incomplete traumatic rupture treated in this way because in the latter there is no loss of a portion of the duct wall.

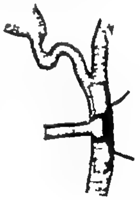

Fig 510.—Treatment of incomplete rupture of the anterior or anterolateral wall of the common bile-duct.

When the rupture is situated on the posterior aspect of the duct, it can be cared for by incising the overlying peritoneum and inserting a drainage tube down to the site of rupture, followed by cholecystostomy as was done in Hicken and Stevenson's case The general peritoneal cavity should be drained, also

A boy aged 7 years, was admitted intensely jaundiced with a distended abdomen, accompanied by persistent vomiting and dehydration a week previously at an outlying farm, he had been involved in a crushing accident to his abdomen.

Immediate treatment consisted of oxygen therapy gastric aspiration, fluid therapy and administration of penicillin. By abdominal paracentesis 3000 ml. of bile was aspirated; this was found to be bacteriologically sterile. After four days pre-operative preparation the abdomen was opened and much bile was sucked from the general peritoneal cavity The lesser sac was also full of bile. Fifty ml. of 70 per cent diodrast was injected into the collapsed gall-bladder and a radiograph was taken. In the film a narrow stream of opaque medium could be seen issuing from the

duct and escaping into the lesser sac. Armed with this information, after incising the peritoneum covering the duct a rupture was located on the posterior wall of the common bile-duct. Cholecystostomy was performed and the lesser sac was drained. On the fifth post-operative day an additional 1500 ml. of bile was aspirated from the peritoneal cavity. A week later a further cholangiogram showed the diodrast passing down the common duct into the duodenum. The tubes were removed and the patient made an uninterrupted recovery.

Complete Rupture of the Common Bile-duct.—Provided the cystic duct is *patent*, which can be ascertained at once by squeezing the gall bladder, the best procedure is to ligate both ends of the common bile-duct, and proceed to perform cholecystjejunostomy (see p. 323).

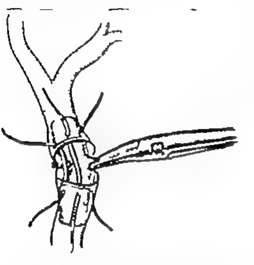

Fig. 511.—Method of repairing a complete rupture of the common bile-duct. After the sutures have been placed, but before all are tied, the tube is removed. This method is only employed if the gall bladder is fibrotic or has been removed previously.

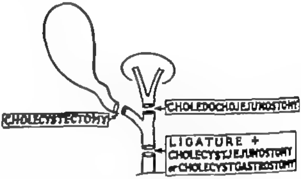

Fig. 512.—A symposium of methods of treating early complete tears of the biliary tract.

Should the gall bladder be diseased, or have been removed previously, the ends of the common bile-duct must be repaired by end-to-end anastomosis (*Fig.* 511). A T-tube is then inserted through a vertical incision in the common bile-duct above, or preferably below, the seat of anastomosis.

TRAUMATIC RUPTURE OF THE ABDOMINAL WALL

Subcutaneous rupture of the abdominal muscles from trauma is very uncommon. R. H. Jamieson's patient, a labourer of 42, was caught between trucks, the left side of his abdomen being crushed by a projecting edge. On admission there was an oval hernia to the left of the rectus sheath. Laparotomy showed that the aponeurosis of the external oblique, the internal oblique and the transversalis had all been torn, as well as the peritoneum, which allowed a loop of intestine to escape subcutaneously. Repair of the rupture was straightforward.

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CHAPTER XXXI

PENETRATING WOUNDS OF THE ABDOMEN

"It is safer to look and see than to wait and see." (*Sir Cuthbert Wallace*)

During the Second World War the very considerable reduction in mortality from war wounds of the abdomen was due to adequate resuscitation and skilful anæsthesia, to the adjuvant effect of sulpha drugs and antibiotics, to the use of continuous post-operative gastric suction and intravenous fluid replacement, and last, but not least, to the adoption of the principle of exteriorization of the large bowel advocated so vigorously by Sir Heneage Ogilvie. Since then, further developments in intravenous fluid therapy and the wider use of thoraco-laparotomy have played their part in further reducing the mortality associated with these grave injuries.

Diagnosis.—The majority of penetrating wounds of the abdomen present no difficulty in diagnosis, the wounds of entry and exit marking only too clearly the path of destruction and the viscera likely to have been involved. When the missile is retained within the abdominal cavity and the wound of entry lies on the periphery it is essential to ascertain the exact posture of the patient at the time of wounding, and the direction from which the missile came in order to surmise its probable course within the abdomen. It should be remembered that missiles entering the supraclavicular or popliteal fossæ have at times terminated their course in the abdominal cavity, that 30 per cent of wounds of the buttock are accompanied by intraperitoneal or intrapelvic lesions, and that over 10 per cent of thoracic wounds involve the abdomen in addition.

In the early stages after wounding physical signs of involvement of a viscus are misleading. Rigidity is not often present in the early stages. Vomiting, unless it contains blood, is of little diagnostic value, and diminution of liver dullness is not often present when a hollow viscus has been perforated by a missile. When the diagnosis is in doubt, the presence or absence of bowel sounds is of some diagnostic value, but it is essential to listen for these for a full minute. When large bowel alone has been involved, bowel sounds may indeed still be present—a trap for the unwary. In all cases, the urine must be examined for blood, and a rectal examination must be carried out. X-ray localization of foreign bodies, if feasible and considered essential, should be undertaken preoperatively in the anæsthetic room to avoid unnecessary movement which these patients stand badly.

PRINCIPLES IN TREATMENT

Urgent though operative treatment of penetrating abdominal wounds may be, the first essential is to establish and maintain adequate resuscitative measures with blood, dextran, or plasma. These patients are always shocked to a greater or less degree, and it has been well said that "if the patient has cold feet, the surgeon would do well to develop cold feet until the patient's feet have improved." As a general rule, no surgical procedure should be commenced until the systolic blood pressure is at least 100 mm. Hg. The one exception is when the patient's blood pressure fails to rise despite speedy and adequate transfusion of up to 12 pints (6.8 litres) of blood in the course of one to two hours. Such a patient is suffering from a major internal hæmorrhage, usually from the spleen or from torn mesenteric vessels. To save his life he requires not only resuscitative measures, but an immediate operation to control the bleeding vessel or vessels.

Autotransfusion.—Three hundred and thirty-six cases of gunshot and stab wound of the abdomen occurring at Louisville City Hospital were reviewed by *Hamilton* and *Duncan*, who made great use of autotransfusion. What is astounding is their statement that, if the injury is not of more than six hours' duration, contamination of the blood by bowel content does not seem to matter. On opening the abdomen, free blood was sucked out of the peritoneal cavity into a receptacle containing citrate solution. The resulting mixture was poured through ten thicknesses of gauze and then transfused. E. Gratton, dealing with Mau Mau casualties in Nairobi, had similar gratifying results.

Contra-indications to Operation after Resuscitation.—

1 Late cases receiving wounds thirty-six hours or more previously and obviously improving are best treated conservatively Similar cases not improving but showing evidence of localization, may be treated in a like manner

2. Wounds caused by shot from a sports gun (q v).

Débridement of the Wounds of Entrance and Exit Prior to Laparotomy.—Before commencing laparotomy débridement of the wound of entry and of the wound of exit if there is one, is a matter of cardinal importance These wounds are excised in the usual manner (*see* p. 134) down to and including, the peritoneum. The wound or wounds are then packed temporarily and gloves, instruments, and towels are changed. After concluding the intra abdominal operation and closing the laparotomy incision, the packing referred to is removed. The edges of the peritoneum in the depths of the wound are approximated by sutures, and the wounds are packed with petroleum-jelly gauze Unless infection supervenes, delayed primary closure of these wounds is undertaken within a week.

LAPAROTOMY

The Incision.—A careful estimate of the wound track and of the organs likely to be involved is a prerequisite to the correct placing of the abdominal incision. When there are wounds of entry and exit on opposite sides of the abdomen, a midline incision centred on a line joining these wounds is needed. When there is an entry wound only a similar incision centred on a line joining this with the estimated site of the missile is required The incision should curve 1 in (2 5 cm.) away from and avoiding the umbilicus, and should rarely exceed 7 in. (17 5 cm) (*Fig* 513) In closure the peritoneum should be securely sutured with a continuous interlocking stitch. The aponeurotic layer and skin require interrupted stainless-steel wire through and through sutures (*Fig* 514) the edges being approximated with interrupted thread Drainage of the fascial layer is advisable if there has been leakage of intestinal contents. Paramedian rectus-splitting and rectus displacing incisions have no advantage over the midline approach which is no more liable to the development of incisional hernia.

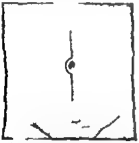

Fig 513.—Standard incision for exploratory laparotomy in the case of a penetrating wound of the abdomen.

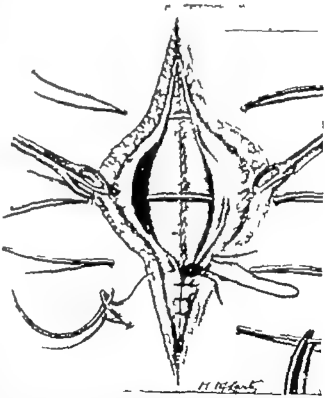

Fig. 514 —Closing the incision. The peritoneum has been approximated by a continuous catgut suture The aponeurosis is being brought together by interrupted cotton sutures. Four through-and-through stainless-steel sutures are in place (*Surgery of Modern Warfare*)

When entry and exit wounds are on the same side of the abdomen, and consequently are comparatively close together the skin incision for exploration should encircle and join the two, and the wound should be excised thoroughly in layers. It will soon be apparent whether the abdominal cavity has been involved in the wound, and if not, an unnecessary opening of the peritoneum is avoided. If it is, the incision is elegantly placed over the viscus involved. It may be enlarged if necessary with ease

In wounds of the flank involving the large bowel, kidney or spleen, a transverse incision from the outer border of the rectus passing midway between the twelfth rib and the iliac crest, ending at the outer border of the erector spinæ gives a very satisfactory exposure (*Figs.* 315, 316). The wound is closed in layers with drainage but its posterior part may be left open when there has been an extraperitoneal wound of the colon.

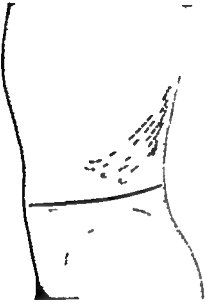

Fig. 315.—The lateral transverse incision

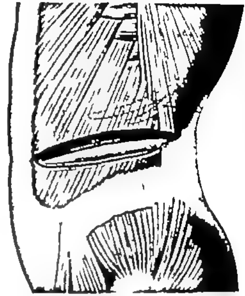

Fig. 316.—All the lateral musculature between the edges of the rectus muscle in front and the erector spinæ behind are divided. (*Surgery of Modern Warfare.*)

Procedure.—When there are associated injuries of the back or buttock, these should be dealt with first unless the case is one of immediate urgency to control hæmorrhage. The need for turning the patient on to his abdomen after laparotomy is thus avoided.

On opening the abdomen the source of any hæmorrhage present must firstly be found and controlled. If there is a fæcal odour denoting a lesion of the large bowel, this is identified. Should there be other injuries the wound of the large bowel is packed off and dealt with last. The liver, spleen, and kidneys are next examined and any injuries found are dealt with. This is followed by definition and treatment of wounds of the small intestine. If the missile is met with in the course of this exploration, it is of course removed but the operation should not be prolonged unnecessarily by a meticulous search for it. When a wound of a hollow viscus has been repaired, it is desirable that the affected area be drained. This can be carried out effectively by a rolled corrugated rubber drainage tube brought out through a separate stab incision in the flank. Should the retroperitoneal spaces be involved, it is absolutely essential that very free drainage be provided to these easily infected areas. This call for retroperitoneal drainage holds good when large bowel has been exteriorized, a drainage tube being brought out alongside the lateral aspect of the gut. Drainage is also required in wounds of the liver, spleen, bile-ducts, and pancreas.

WOUNDS OF THE MESENTERY

These are the second most frequent cause of hæmoperitoneum, the first being injuries of the liver and spleen. Bleeding points in the torn mesentery are carefully picked up and tied, avoiding injury to other mesenteric vessels. The viability of the corresponding portion of the small intestine must be closely observed. When there are no colour changes, nothing need be feared. Pallor or cyanosis are signals that resection must be performed unless the general condition is so poor that a risk must be taken. When the rent is near the mesenteric border of the gut (*Fig.* 317), and exceeds 1½ in. (3·8 cm.) resection is usually needed.

In the mid-section of mesentery the collateral blood-supply in tears of moderate size, is usually sufficient to enable hæmostasis and suture to be undertaken. When the wound is close to the root of the mesentery a torn vessel places a large segment of gut in jeopardy and wide resection is usually needed. Ecchymoses and small hæmatomata may be disregarded, but large hæmatomata must be evacuated and the offending vessel sought. The superior mesenteric vessels are compressed (*Fig.* 518) the clot is wiped away and on

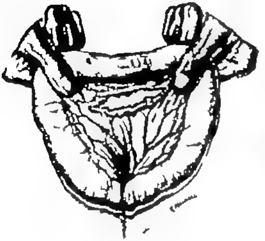

Fig. 517.—Type of wound of the mesentery which makes resection inevitable. (*Surgery of Modern Warfare.*)

Fig. 518.—The peritoneum over a large mesenteric hæmatoma has been incised. The blood-clot is evacuated while the superior mesenteric vessels are compressed.

momentarily releasing the vessels the torn artery declares itself and is picked up and tied. Accurate ligation preserves the maximum amount of intact arterial tree and may obviate the necessity for resection. After ligation the corresponding segment of small bowel must be watched closely for colour changes.

RETROPERITONEAL HÆMATOMA

Except when in close relation to the colon, small hæmatomata can be left alone. Large hæmatomata which are increasing in size may on occasion demand evacuation and ligation of the bleeding vessel. The overlying peritoneum is incised, and as the source of the bleeding is very variable, the surgeon must steel himself to act calmly and purposefully should the wound involve the renal pedicle, the vena cava, or the iliac vessels. Digital pressure between finger and thumb will control any hæmorrhagic cascade. With efficient swabbing on the part of the assistant the bleeding vessel can usually be dealt with effectively.

If there is much associated bruising of the large bowel, it is often prudent to perform temporary cæcostomy.

WOUNDS OF THE LARGE INTESTINE

There are certain special features of these wounds which render their treatment difficult and at times hazardous. The wound, often solitary, is commonly retroperitoneal and thus liable to be missed, the only clue to its existence being a retroperitoneal hæmatoma. The bowel wall is thin, and extensive bruising around the lacerated area renders suturing of the wall insecure. Secondary perforation in the bruised area, the flooding of the peritoneal cavity with highly fluid fæcal material and the development of lethal infection in the retroperitoneal tissues after mobilization of the affected portion of the large bowel add to the gravity of these cases. For these reasons the treatment of choice for lesions from the hepatic flexure onwards is to exteriorize it *in toto* through a separate stab incision (*see Fig.* 504, p. 384).

Before passing the loop to be exteriorized through the stab incision a spur may be formed by joining the antimesenteric borders of the limbs of the loop together for 4 in. (10 cm.) (*Fig* 319). This spur is crushed later when the colostomy is to be closed. The formation of a spur is not essential and should it be difficult of execution owing to tension it is better to omit it In such cases subsequent closure of the colostomy by excision and end to-end anastomosis is now practised safely

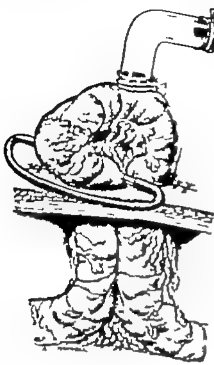

Fig 319 —Exteriorization with spur formation (the Paul-Mikulicz operation).

Lesions affecting the descending colon should be approached extraperitoneally With the patient partly rolled over to the sound side, a separate transverse incision (*see Figs.* 313 316) made well towards the flank provides access to a perforation which would otherwise be quite inaccessible

Wounds of the cæcum and ascending colon present peculiar difficulty owing to the dehydration and skin excoriation which follow exteriorization of this portion of large intestine. In cases with considerable bowel-wall destruction, resection of the cæcum and right colon, with ileotransverse colostomy is indicated if the patient's condition will allow Alternatively the injured segment is exteriorized and a short-circuiting ileotransverse colostomy performed A third plan is to resect the injured segment and to exteriorize both ends with the addition of an ileotransverse colostomy to short circuit the wounded segment In minor cases a two-layer repair with unabsorbable sutures, covered by an omental graft and with an associated temporary cæcostomy is the treatment of choice When this portion of the gut is exteriorized the skin should always be protected from excoriation by the use of aluminium hydroxide paste

WOUNDS OF THE RECTUM

Intraperitoneal wounds of the rectum should be repaired with a double layer of sutures followed by a proximal colostomy as near to the injured gut as is practicable In extra peritoneal wounds colostomy is performed, but no attempt is made to repair the injured intestine The widest possible drainage of the perirectal tissues must be established. This is accomplished by excision of the coccyx, division of the fascia of Waldeyer and the opening up of perirectal tissues by finger dissection. By these means the best possible dependent drainage is obtained (*Fig* 320).

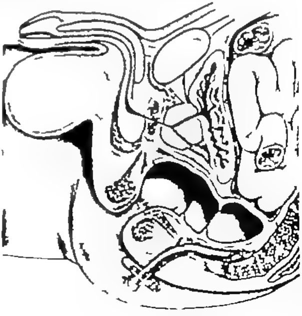

Fig 320 —Drainage of the pararectal extraperitoneal tissues after removal of the coccyx.

WOUNDS OF THE SMALL INTESTINE

The lesions are almost always multiple; the average number in the case of a bullet wound is four, but there may be as many as twenty. Generally it is best to commence by examining the intestine at the ileocæcal valve and to work upwards, but on occasion common sense dictates that to commence at the duodenojejunal flexure and work downwards will be the procedure of choice. In either case the whole length of the small intestine must be examined. In no circumstances should evisceration be practised. Deft segmental scrutiny is the procedure to be adopted. After the integrity of each 8–10 in. has been verified it is replaced by the surgeon or his assistant. When a wound is found it may be repaired at once. Alternatively the whole length of the gut may be examined first, perforations being marked with fine forceps as they are found. The mucosa is well inverted, and the perforations are closed transversely (*Figs.* 521, 522) to avoid stenosis. When there is a number of perforations in a relatively small segment, closure of each by a single layer of thread suffices. In more isolated lesions a double layer of thread is used. When there are perforations close together it is desirable that they be repaired if possible in preference to carrying out a resection, as the mortality associated with the latter is quite double that of suture. However, resection is demanded when:—

Fig. 521.—An oblique wound about to be repaired in the transverse axis of the bowel. (*After Grey Turner.*)

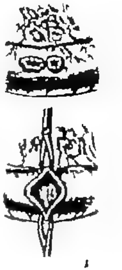

Fig. 522.—Two small wounds converted into one, ready for suture in the transverse axis. (*After Grey Turner.*)

1. The gut is separated from its mesentery for more than 1½ in. (3·8 cm.).
2. The suturing of multiple wounds close together would inevitably lead to a gross stenosis.
3. The gut is extensively damaged as well as perforated.
4. Infarction.
5. When the perforation is along the mesenteric border of the intestine and consequently its viability is in doubt.

After resection, an end-to-end anastomosis should be carried out.

WOUNDS OF THE STOMACH

These are commonly encountered in thoraco-abdominal injuries. There is always considerable bleeding. Both surfaces of the viscus are involved. The wound in the posterior wall is approached through the greater omentum. Should it be difficult to find, it may be located by passing a finger through the wound in the anterior wall. Repair should always be carried out by an inverting suture in two layers.

WOUNDS OF THE DUODENUM

These carry a very heavy mortality owing to injury of neighbouring vital structures, and difficulty of closure. Approach is greatly facilitated by medial mobilization of the hepatic flexure of the colon. The wound, which is not infrequently on the posterior wall of the second part, should be closed with at least a double row of sutures. If considerable stenosis is likely to result, gastrojejunostomy should also be carried out. The retroperitoneal tissues must be drained freely through the flank.

WOUNDS OF THE SPLEEN AND PANCREAS

Wounds of the spleen and pancreas require no special mention, for their treatment is identical with that of closed injuries of these organs (see Chapter XXXIV).

WOUNDS OF THE KIDNEY

Conservative treatment is indicated in minor wounds of the kidney. If appreciable bleeding continues after 24 hours, the organ should be explored. Large wounds in the renal area are explored as part of routine wound treatment. If damage to the kidney is minimal, the area is drained. In a penetrating wound of kidney, nephrectomy is indicated if the ureter is divided, if the renal pelvis or renal pedicle is involved, or if there is parenchymatous involvement of half or more of the renal substance. For the indications for partial nephrectomy see p. 390.

WOUNDS OF THE LIVER

These wounds should as far as possible be treated conservatively, but involvement of other abdominal organs may necessitate laparotomy. When so met with, the tear should be packed firmly with absorbable gauze, and the region of the tear drained through the flank. Gauze roll packs and attempts at suturing are to be avoided. When there is a thoracic wound of entry, the usual wound revision will expose the tear in the diaphragm, and through this, at times, an accessible missile may be removed. No exploration of the track in the liver should be carried out. The diaphragm is repaired and the thorax closed.

THORACO-ABDOMINAL INJURIES

In thoraco-abdominal wounds, which represent over 10 per cent of penetrating abdominal injuries, the missile penetrates the chest and diaphragm and may emerge through the abdominal wall or be retained in the abdomen. Conversely, a missile entering the abdomen may pass through the diaphragm and either end in the thorax or emerge through the chest wall. Such an injury is referred to as an abdomino-thoracic wound and carries a heavier mortality than either an abdominal or a thoracic wound. Considerable damage is often caused by the missile, and by indriven rib fragments, to the lung and diaphragm, and to the liver, stomach, spleen, kidney, and transverse colon.

Diagnosis.—In the majority of cases the direction of the path of the missile will indicate the nature of the abdominal damage. When the missile is retained, X-ray examination is essential to locate it. Clinically, it should be remembered that abdominal rigidity due to thoracic injury is usually unilateral and there is some relaxation during inspiration, whereas with involvement of a subdiaphragmatic hollow viscus it is generalized and constant. Bowel sounds will be present on auscultation if the abdominal contents have escaped uninjured. If the diaphragm has been involved, there is often a catch or hiccup at the end of inspiration and pain may be referred to the shoulder.

Treatment.—If there is an open sucking wound of the chest, this must be sealed off at once by a large occlusive dressing, stitched into position if necessary, as a temporary measure. The patient is often shocked and dyspnoeic owing to the pleural cavity being full of blood. This should be aspirated as soon as possible as a resuscitative measure. Blood should only be transfused in amounts to replace blood lost and only at a rate of about a pint an hour. The condition of the opposite lung must be carefully checked, as it may be the site of blast contusion or collapse, and may preclude operation.

In the first place, if there is an open wound of the thorax, this assumes surgical priority and must be dealt with at once. However, in right-sided wounds, with no significant thoracic damage, and with intra-abdominal injury confined to the liver alone, conservative treatment of the lesion should be adopted. In similar cases, but with thoracic-wall damage requiring wound revision, the liver may be inspected through the diaphragmatic rent, and an accessible foreign body removed. No extensive search for the missile should be made, neither should the wound track in the liver be explored, curetted, or otherwise interfered with. The rent in the diaphragm should be repaired and the chest closed.

It is in left-sided thoraco-abdominal wounds, where there is major thoracic damage and which also involve the stomach, spleen, transverse colon, or splenic flexure, that the operation of thoraco-laparotomy so greatly facilitates the work of the surgeon.

THORACO-LAPAROTOMY

The operation here described is the full operation to expose widely and simultaneously the thoracic and abdominal cavities and is the same incision, used in other circumstances,

for procedures such as radical total gastrectomy The extent to which the full incision is required will depend on the nature and extent of the injuries found. When the damage is mostly thoracic, and access is required only to the fundus of the stomach or spleen the incision need not cross the costal margin, the latter organs being approached by enlarging the diaphragmatic wound

Fig 523.—Incision for thoraco-laparotomy

Position.—The patient is placed in a right lateral position, the left arm on an arm support, the right knee bent and the left lower extremity extended. Sometimes the patient is tilted backwards so that the abdominal part of the operation is easier of access, but this is not essential.

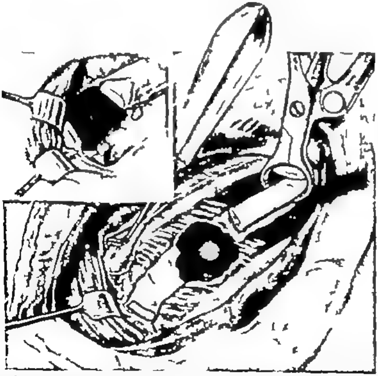

Fig 524.—Transthoracic laparotomy The *external wound, including a piece of shattered rib, has been excised.* With fresh instruments, more of the rib is removed. The rib above is divided near the posterior end of the wound, in order to allow a good view of the interior by suitable retraction. *Inset* The rib above divided, and its intercostal vessels ligated.

Incision.—The incision commences in the midline at a point in the line of prolongation of the 8th rib[1] It crosses the left rectus and left hypochondrium obliquely to the left costal

[1] The 9th rib gives better access to the abdominal cavity the 8th rib to the thoracic cavity

margin and continues in the line of the 8th rib to end 1½ in. (3 8 cm.) medial to the lateral border of the sacrospinalis (*Fig* 323). The incision is deepened down to muscle. The whole of the abdominal musculature in the line of the incision, including the left rectus is divided preferably with diathermy The periosteum of the 8th rib is then divided in the line of the rib and is reflected with a sharp curved raspatory The rib is freed from the posterior periosteum and intercostal vessels by a curved Doyen s rib raspatory inserted at the posterior end and pushed forwards towards the costal cartilage. The posterior end of the rib is divided by a costotome or rib shears and the rib with its attached costal cartilage is excised (*Fig* 324) The incision is then carried down across the costal margin and the peritoneal cavity opened freely The pleural cavity is opened through the bed of the rib, and the upper surface of the diaphragm exposed. The left pulmonary ligament is divided and the left lung packed off lightly

Dividing the Diaphragm.—The diaphragm is divided at right angles to the line of the original incision towards and up to the œsophageal hiatus. As it is divided, thread or silk sutures are passed through the cut edges on each side the ends being left long. These secure hæmostasis and act as retractors. When division is complete the edges can be stitched temporarily to the parietal muscles of the chest wall and of the abdominal wall, so increasing the width of the wound. The pleural and peritoneal cavities are now joined and a wide operating field is available. Retractors are usually unnecessary (*Fig* 325).

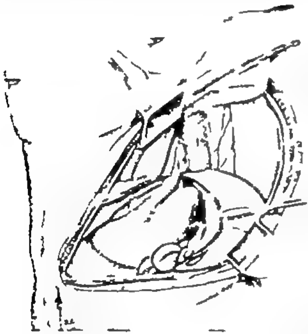

Fig 323.—Left thoraco-abdominal incision. Showing the splendid access to the thorax and the viscera of the upper abdomen.

(*Painting by Capt D B Clarke, R.A.M.C*).

Closure.—The diaphragm is closed by a close series of interrupted silk sutures. When necessary drainage of the intra-abdominal operation site is carried out, and the tube is made to emerge below the tip of the 12th rib. The peritoneum is closed and an accurate layer by layer repair of the divided abdominal musculature is performed. The pulmonary ligament is sutured, and a scrupulous but gentle cleansing of the pleural cavity carried out. The phrenic nerve should not be crushed. An intercostal catheter is placed in position and the rib bed sutured. At this stage the anæsthetist clears the bronchial tree by intermittent suction through the endotracheal catheter or a bronchoscope before fully re-inflating the lung The spigot is placed in the intercostal catheter and the thoracic parietal musculature is then repaired in layers. The skin incision is closed, and the intercostal catheter is connected to an under water seal. When possible a radiograph to confirm full re-expansion of the lung should be taken before the patient leaves the operating theatre.

SHOTGUN WOUNDS

When, as the result of being peppered by a shotgun, a patient receives scattered penetrating wounds of the abdomen, it is justifiable to adopt a conservative attitude as the intestinal wounds caused are so minute that they are virtually self-sealing The patient is placed on continuous gastric suction and intravenous therapy for three days, being observed closely the while In very few cases, if any will surgical intervention be required.

Close-range injuries from a shotgun, of course require the same urgent treatment as any other penetrating wound

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Revised by Lieut.-Col. AUSTIN DEMPSEY O.B.E., F.R.C.S. (Eng.),
Royal Army Medical Corps. Senior Surgeon Cambridge Military Hospital, Aldershot

CHAPTER XXXII

RESECTION OF GUT

GENERAL EMERGENCY MEASURES

To be able to resect irreparably damaged intestine and restore the continuity of the gut expeditiously is an acquisition expected of every emergency surgeon but to know how and when to adopt a less drastic alternative procedure is an even greater accomplishment.

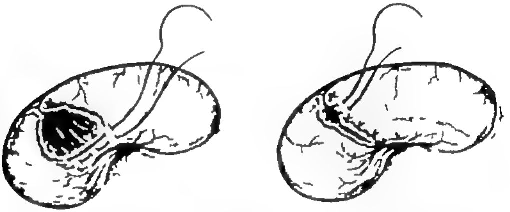

Fig. 326.—Infolding a small gangrenous patch. (*After O. H. Wangensteen.*)

a. A Small Gangrenous Patch not greater than ½ in. (1.3 cm.) in diameter can be treated by invagination. For this purpose mattress sutures cannot be bettered. In *Fig.* 326 it will be noticed that the suture nearest the mesentery (on either side) is what

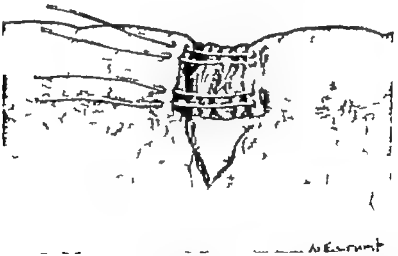

Fig. 327.—Treatment of localized annular gangrene (I). A V-shaped piece of mesentery is excised and mattress sutures are placed as shown.

Wangensteen calls a 3-2-stitch three bites going and two returning. The rings of constriction on the intestine so noticeable after the release of a tight strangulated hernia (*see Fig.* 678) are embedded in the same manner.

b **Treatment of Annular Gangrene of Small Intestine by Invagination.**—"Experience has taught me that when the gangrene is limited and annular in type it may be handled more safely by invagination than by resection" (*J E Summers*) It is seldom that a typical case is presented in which this method is indicated but there is little doubt that invagination in properly selected cases has saved many lives.

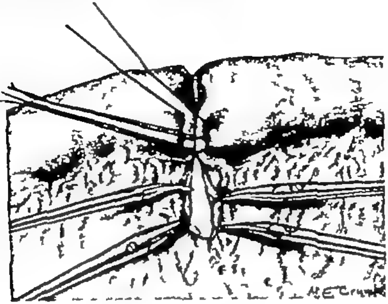

Fig 328.—Treatment of localized annular gangrene (II). Interrupted cotton sutures completing the invagination.

Invagination is *contra-indicated* in the following conditions (1) When the segment of gangrenous intestine is longer than 2 in. (5 cm.) (2) When there is much œdema of the intestinal wall (3) When the gut above is very dilated and the gut below collapsed. These contra indications must be noted carefully I have attempted to invaginate an

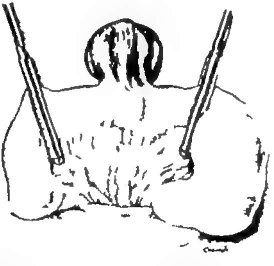

Fig 329 —A gangrenous Richter's hernia should be dealt with by excising the gangrenous portion only and repair of the defect in the *transverse* axis of the intestine

œdematous piece of intestine but when the invagination was completed it was obvious that the lumen was practically blocked, consequently resection had to be undertaken after all.

The technique of invagination is illustrated in *Fig* 327 A V-shaped piece of mesentery the base of which corresponds to the gangrenous portion, is excised. By means of four sutures, applied as shown, the gangrenous portion is tucked in, and interrupted cotton sutures (*Fig* 328) complete the anastomosis. The gap in the mesentery is closed.

The type of case in which the invagination may be used occurs particularly in strangulated *femoral hernia, and if Lotheissen's or Hey Groves operation for femoral hernia* has been employed there will be no difficulty in returning the somewhat bulky segment into the peritoneal cavity When the method is employed in connexion with inguinal hernia, one must be sure that the constricting ring of the hernial sac is dilated widely before attempting to return the loop. If this has to be pushed through a narrow neck, the line of suture may be disturbed.

c. **In a Gangrenous Richter's Hernia** resection of the gangrenous diverticulum (*Fig.* 520) followed by transverse closure of the defect, is all that is necessary When possible a free omental overcoat should be stitched so as to reinforce the suture line and minimize adhesions.

EXTRA ABDOMINAL RESECTION AND ANASTOMOSIS

Extra-abdominal resection and anastomosis is the method *par excellence* when the patient is in poor condition, the abdomen greatly distended, and the gangrene does not extend far into the mesentery The gangrenous coil is delivered on to the surface with about 5 in (12 5 cm) of viable bowel on either side. The abdomen is closed completely about the coil. Resection of gangrenous intestine is then performed. An end-to-side anastomosis is

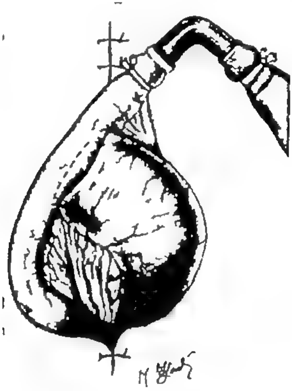

Fig 530 —Extra-abdominal resection and anastomosis of the proximal end into the distal end, with enterostomy

made between the distended proximal limb and the contracted distal limb, the free end of the T being used as an enterostomy : into the open end is tied a Paul's tube The anastomosis is, of course left outside the abdomen (*Fig* 530). If all goes well four or five days later the enterostomy can be closed and the exteriorized portion returned to the abdomen. The remainder of the abdominal wall is closed with corrugated rubber drainage

RESECTION AND ANASTOMOSIS

On Intestinal Clamps.—In the description of resection of the gut that follows shortly it is assumed that the operator is equipped with light rubber-covered intestinal clamps and crushing clamps, but there is no need to become apprehensive if such instruments are not to hand. For resection of the small intestine, a hæmostat can take the place of a crushing clamp.

Intestinal clamps can be dispensed with if the excellent expedient of cutting two strips of foam rubber to the size of the circumference of the intestine is employed. Each strip is kept compressing the intestine where desired by a stitch passing through an avascular part of the mesentery very near its junction with the intestine and tied over the sponge (*Fig* 531). Berman and Mainella prefer this method to the use of clamps, especially in babies.

Resection.—It is as easy to resect 2 ft (60 cm.) as 2 in. (5 cm) It is of fundamental importance to realize this when deciding how much small intestine should be resected Obviously one can afford to err on the side of liberality and an extra few inches resected often ensures healthy intestine for the anastomosis. In necessary cases, enormous lengths of the small intestine must be sacrificed. If on opening the abdomen many feet of gangrenous gut are encountered, it is quite wrong gravely to shake one s head and, with an utterance of regret to close the abdomen, as I have seen done. Many patients who have had up to 20 ft (6 1 m.) of small intestine resected have survived some of them have remained in good health.

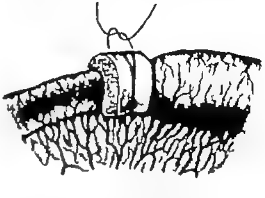

Fig 531 —A piece f foam rubber can be used in *this way as a most effective substitute for an intestinal* clamp (*After H Berman and F S Mainella.*)

Having decided how much to resect a rubber-covered clamp is placed on the distal point then, stripping back the intestinal contents a second clamp is applied at the proximal point. The arc to be resected is isolated carefully by moist packs.

The first step in resection of gangrenous intestine is to divide its mesentery If the viability of the mesentery is dubious, it is of the highest importance that it should be excised in a V-shaped manner Provided the mesentery is healthy proceed as follows: At the lowermost point of the proposed section a hæmostat is driven through the mesentery near the intestine (choosing an avascular spot if possible). Clipping, then cutting the mesentery is freed from the intestine (*Fig* 532). Then the mesentery is tied off Each hæmostat is picked up in turn, and the mesentery which it grasps is transfixed and ligated.

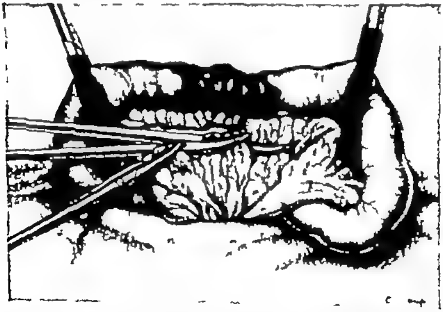

Fig 532.—Resection of gut. The first step is to divide the mesentery In a case of gangrene strictly localized such as this, 6 in. (15 cm.) of gut proximal to the gangrene and 2 in. (5 cm.) of gut distal t the gangrene should be sacrificed.

A crushing clamp is applied at each end of the freed segment of intestine. The point at which the crushing clamp is applied must have a good blood-supply—in other words, it should be close up to that portion of the intestine which has its mesentery still intact.

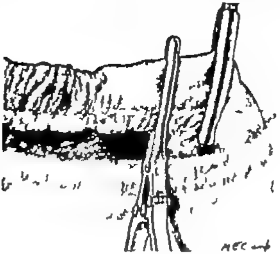

Fig. 533.—The relative positions of the clamp and the crushing instrument. Note that the crushing instrument is applied near the intact mesentery.

Fig. 533 shows the relative positions of the rubber-covered clamp and the crushing instrument. A length of gauze is tucked under the mobilized gut, hiding and protecting the divided mesentery. In order to prevent escape of intestinal contents at each end a long hæmostat is applied close up to the crushing clamp (*Fig.* 534). If available the

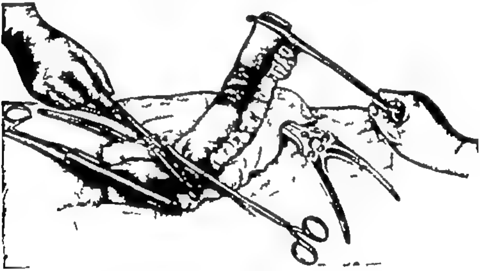

Fig. 534.—Excising the segment of intestine.

intestine should be severed with a diathermy needle; failing that a scalpel run down the surface of each crushing clamp immediately frees the portion to be resected (*Fig.* 535). This, with the scalpel, is cast into a bowl away from the field of operation. The surface of the clamp is swabbed lightly with spirit.

END-TO-END ANASTOMOSIS OF THE SMALL INTESTINE

What is of absolutely fundamental importance is to ensure that the ends of the intestine are severed obliquely—the obliquity receding from the mesenteric to the antimesenteric borders. The obliquity of the severed distal (contracted) end must be

especially noticeable: the smaller its lumen, the greater the obliquity. This point is brought out in *Fig* 535.

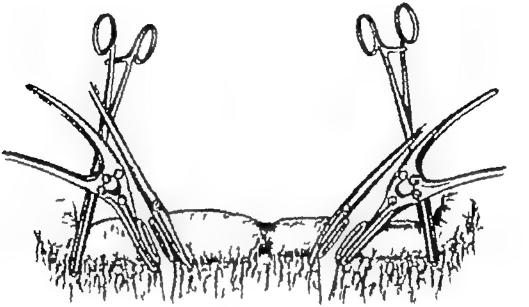

Fig 535.—Relative position of instruments during resection of a segment of small intestine. The obliquity of the cut surfaces is preparatory to end to-end anastomosis.

1. The crushing clamp is removed, and the end of the gut will be found to be sealed. This sealed, crushed surface is picked up with hemostats at each end, and the edges are prized apart with a Watson-Cheyne dissector. The interior of the intestine is swabbed dry with pledgets of gauze (*Fig* 536). If a severed end is considered to be insufficiently oblique, it is trimmed with scissors until the desired angle is obtained.

Fig 536.—Cleansing the interior of the gut distal to the clamp preparatory to end-to-end anastomosis. When fecal matter is removed neomycin can be applied within.

2. The little triangle at the junction of the gut and its mesentery which has so well earned the name of the danger area (*Fig* 537) is picked up in a hemostat, crushed and ligated.

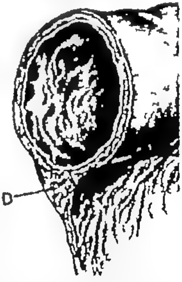

Fig 537.—The danger area (D) is picked up in a hemostat, crushed, and ligatured.

3. Two well soaked intestinal catgut sutures with eyeless needles are taken and their free ends knotted. The knot should be trimmed and tested.

4. The rubber covered clamps are brought together and adjusted so that the cut surfaces of the intestine lie parallel with one another. Both needles of the intestinal suture just mentioned are passed close to one another through the whole thicknesses of the intestinal walls and a knot is tied. *Fig* 538 will make this clear.

END TO-END ANASTOMOSIS

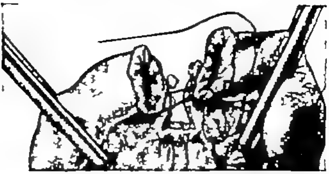

Fig 538.—End-to-end anastomosis. The posterior layer completed. The stitch passes through all coats of the intestine

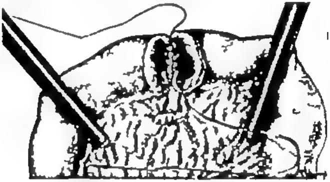

Fig 539.—End-to-end anastomosis. The first stitch, which is placed to one side of the ligated danger area, is shown.

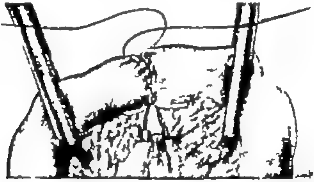

Fig 540.—End-to-end anastomosis. The anterior row is completed and meets its fellow suture at a point diametrically opposite the first stitch.

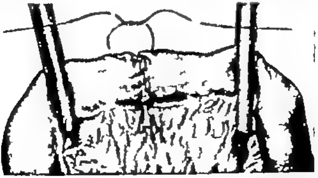

Fig 541.—End-to-end anastomosis first layer completed by burying the knot. The suture line is reinforced by a second serosal layer of fine unabsorbable sutures.

5 From this fixed point each needle with its suture is used to stitch one half of the circumference of the intestine, the lowermost side being stitched first (*Fig* 539) The stitches pass through the whole thicknesses of the gut and are of the over-and-over type, but a back-stitch is taken at every fourth or fifth in order to lock the line of suture and prevent a purse-string effect with its inevitable narrowing of the lumen.

6. The stitching is completed at a point diametrically opposite the point at which it was begun (*Fig* 540) A knot is tied Finally the needles pass through the serosal and muscular coats over the knot and a last knot is tied burying the former (*Fig* 541)

7 *Closing the gap in the mesentery* If a needle is passed through the mesentery there is always the danger of pricking a blood vessel and thereby imperilling the vitality of the gut. A better method is illustrated in *Fig* 542. One ligature is thrown around two pairs of forceps, one pair being applied to each cut surface. Two or three ligatures tied in this way will close the gap in the mesentery effectively

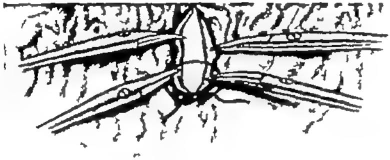

Fig 542.—Closing the hole in the mesentery This is a better method than using a needle, which may pierce a blood-vessel.

LATERAL ANASTOMOSIS OF THE SMALL INTESTINE

In the event of disparity between the diameters of the divided ends of the intestine too proximal for the contemplation of ileocæcostomy lateral anastomosis of the small intestine is a safe procedure. Because the divided ends of the small intestine (they should not be divided obliquely) must be closed (*see Fig* 545), the operation takes longer to perform than end-to-end anastomosis. About 5 in. (12·7 cm.) of the closed ends of the intestine are laid parallel to one another viz. 

The performance of the anastomosis is shown clearly in *Fig* 543.

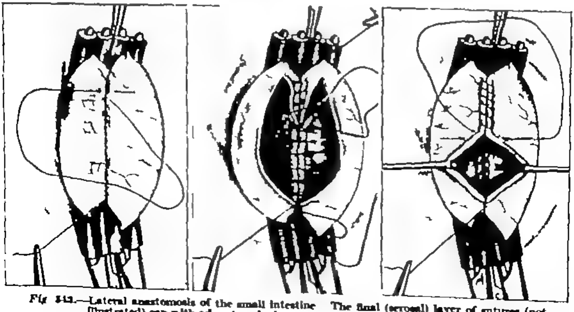

Fig 543.—Lateral anastomosis of the small intestine The final (serosal) layer of sutures (not illustrated) can with advantage be interrupted mattress sutures of cotton.

Poth's Method of Performing Intestinal Anastomosis serves to eliminate the blind ends of side-to-side anastomosis. Not only does it attain this objective but it possesses the advantages of end-to-end anastomosis without entailing some of its risks, to wit impoverished

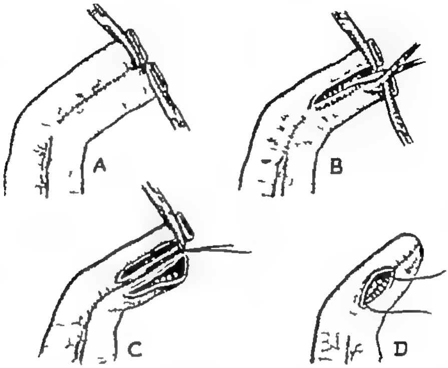

Fig. 844.—Poth's method of performing intestinal anastomosis.

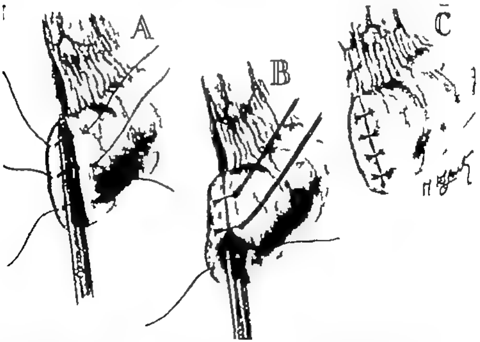

Fig. 845.—A, Three interrupted catgut sutures are so inserted as to invaginate the gut. B, Two of these are tied. The clamp is removed, and then the third suture is tied. C, Further invagination is effected by interrupted cotton stitches. Should speed be a consideration, a continuous catgut suture can be employed for this purpose.

blood supply of the suture line and narrowing of the lumen by infolding. Both's method takes a little longer to perform than end-to-end anastomosis. The technique of the operation is depicted clearly in *Fig.* 544.

ILEOCÆCOSTOMY (ALTERNATIVELY ILEO-TRANSVERSE COLOSTOMY)

Both these forms of anastomosis cause less anxiety than any form of internal intestinal anastomosis. Ileo-transverse colostomy is chosen when the cæcum is inaccessible. The transverse colon being so mobile it can usually be readily brought into the field of operation. Undoubtedly this is the type of anastomosis that should be selected when the portion of gut to be resected comes within 2–3 ft. (60–90 cm.) of the ileocæcal valve.

The resection of an extra few feet of contracted intestine is only a matter of a moment, and the gain is an anastomosis which one feels confident will function if there is even the feeblest peristaltic action. The loss of the ileocæcal valve does not appear to be of any consequence. For the lower ileum this form of resection and anastomosis is second to none.

Technique.—The small gut is resected to within 1 in. (2.5 cm.) of the ileocæcal valve. It is here crushed, ligatured, and the stump invaginated into the cæcum just like the

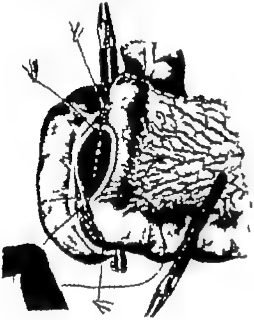

Fig. 546.—Ileocæcostomy in progress.

Fig. 547.—Ileocæcostomy. Anastomosis completed.

stump of an appendix. The proximal end of the small intestine is also closed and invaginated. For closing and invaginating the small intestine the technique shown in *Fig.* 545, A, will be found to be more regularly satisfactory than attempting invagination by the purse-string method. The latter on occasions, especially when the gut is hypertrophied and œdematous, is distinctly difficult. A gastric clamp is then taken and applied to the anterior cæcal wall. About 3 in. (7.5 cm.) of the cæcum are grasped by the clamp and care is taken to avoid the inverted stump of small intestine. The invaginated end of the ileum is laid along the medial border of the clamped portion of the cæcum in such a manner as to make the blind end point towards the hepatic flexure. Having stripped the contents backwards carefully a small clamp is applied transversely about 5 in. (12.5 cm.) from the blind extremity—a second clamp may be applied beyond this for safety. A strip of gauze is tucked under the portions of intestine to be anastomosed, and the whole area carefully isolated with towels. The anastomosis is carried out by the four-stitch method (*Fig.* 546), so well known in gastrojejunostomy. When the gut is opened the mucosa is cleansed carefully. After the anastomosis has been completed (*Fig.* 547), the clamps are removed and the suture line is covered with omentum should this be available.

See also the MAYLARD-SONNENBERG METHOD OF PERFORMING ILEOCOLOSTOMY (p. 434).

RESECTION OF GANGRENOUS LARGE INTESTINE

It is a well proved dictum that after gangrenous large intestine has been resected, primary anastomosis should not be attempted. Resection of a gangrenous portion of the colon and if present, gangrenous mesocolon, followed by the Paul Mikulicz procedure (*see Fig* 519) and, after the abdominal wall has been sutured, the tying in of a tube into the open proximal end of the intestine (*Fig* 548), is the operation of choice

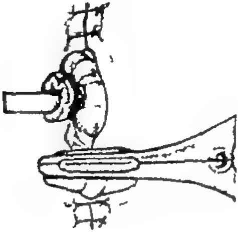

Fig. 548.—Paul Mikulicz operation; first stage completed.

Indubitably healthy bowel is anastomosed for a distance of 3½–4 in (9–10 cm.) in the following manner First the mesocolic borders are approximated, being careful to apply stitching very near the mesocolon, but without encroaching upon that structure with its vital blood-supply Stay sutures, held taut, will help in achieving the correct technique The antimesenteric border of the intestine is next, and easily approximated after stay sutures have been placed. The peritoneum and abdominal wall are then closed about the emerging double-barrelled colostomy (*see Fig* 614 p. 438), care being taken that the mesentery is not included in a stitch. The protruding intestine is excised about 1½ in. (3 8 cm.) above the skin level, its mesocolon is ligated, and a rubber drainage tube or a Paul's tube is tied into the proximal end. About the third or fourth post-operative day an enterotome (*see Fig* 613 p. 433) is applied to the septum separating the two lumina.

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CHAPTER XXXIII

ACUTE INTESTINAL OBSTRUCTION: GENERAL PRINCIPLES

THE most common causes of intestinal obstruction are post-operative adhesions, primary and recurrent carcinoma of the colon, and external hernia, in that order

Acute intestinal obstruction is divided into strangulating obstruction and non-strangulating obstruction. So swiftly is strangulation fatal that even with skilled surgical intervention the mortality of acute intestinal obstruction rises from 4.5 per cent during the first 24 hours to 23 per cent during the succeeding 24 hours, and 45 per cent or higher thereafter It is noteworthy that the chances of survival are as good among patients with strangulating obstructions treated before the stage of gangrene, as among patients with non-strangulating obstructions. Gangrene or perforation of the obstructive bowel leads to a four or five-fold increase in the death-rate

It is true that in most patients with acute intestinal obstruction intestinal intubation, together with intravenous fluid therapy brings about a marvellous change for the better This being so, there is a temptation to pursue these conservative measures for a longer time than is justified in cases where (unknown to the satisfied clinician) strangulation is imminent or has occurred. While intestinal aspiration has brought about an overall reduction in mortality it has also been responsible for an increase in the death-rate among those patients with strangulating obstruction. This leads us to the pertinent question —

How Reliable are the So-called Signs of Strangulating Intestinal Obstruction?

Pain in both strangulating and non-strangulating obstruction is typically colicky In severe strangulation it is sometimes unrelenting

Abdominal or pelvic tenderness is found in 70 per cent of patients with non-strangulating obstruction consequently the belief that the presence of considerable tenderness is indicative of strangulation is erroneous. Three-quarters of patients with intestinal obstruction have abdominal tenderness only a quarter of them have strangulation. Almost 20 per cent of patients with strangulation do not exhibit tenderness (W F Becker)

Elevation of temperature occurs a little more frequently in strangulation than in non-strangulating obstruction.

A pulse-rate exceeding 100 is present in the early stages of about 20 per cent of patients with strangulating obstruction. However roughly the same proportion of patients with non-strangulating obstruction of the same duration also have a pulse-rate of over 100

Leucocytosis is present in about 50 per cent of cases in both conditions.

An abdominal or pelvic swelling is found in about 10 per cent of the strangulated group and in 5 per cent of the non-strangulated group.

A sudden onset is perhaps one of the most reliable factors in differentiating strangulated from non-strangulated obstruction. In strangulating obstruction the symptoms nearly always commence suddenly

Shock occurs early in severe strangulating obstruction. If approximately one-third of the small intestine is strangulated, the amount of entrapped blood lost to the circulation is comparable to that of a severe internal hæmorrhage. When present, early shock is a most characteristic sign of strangulation.

Summarizing So uncertain are the signs of strangulation that a patient with acute intestinal obstruction should be submitted to operation within four hours of admission unless there are adequate reasons for further delay

Ernest H., aged 51 was awakened at midnight 18 hours ago with severe pain in the right iliac fossa, which passed to the left iliac fossa. *The pain was unrelenting and not colicky* He vomited eight times, almost a pint (570 ml.) on each occasion. Thirty years *previously* he had appendicectomy and drainage performed for perforated appendicitis. Since that time he had suffered from recurrent attacks of abdominal pain, which after investigation by barium meal had been diagnosed by many as a neurosis.

On examination The temperature 98 F (36·7° C.) *pulse 110*. The pupils were pin-point (he had been given morphine omnopon, and pethidine). There was tenderness over the lower

abdomen, most marked in the left iliac fossa. Auscultation revealed borborygmi. One hour later the abdomen was opened through a right paramedian incision. There was a volvulus of the terminal ileum, which could not be untwisted easily [1] Twenty inches (50 cm.) of gangrenous intestine resected. Ileocolic anastomosis. On the fourth post-operative day (*Fig* 549) there was an excellent result to an enema. Thereafter recovery was uninterrupted.

Fig 549.—Ernest H. Strangulating obstruction due to volvulus of the lower ileum (with gangrene). Resection. Ileocolostomy

RADIOLOGICAL DIAGNOSIS OF INTESTINAL OBSTRUCTION

Films taken in bed are often indistinct and if possible it is a great advantage to have the services of a radiologist to interpret them. Obviously if the patient is well enough to be moved to the radiological department films taken with the aid of a Potter Bucky diaphragm can give much clearer definition than those taken with a portable unit. If an enema is given and incompletely expelled before the film is made it may produce fluid levels in the colon and provide the basis for an erroneous diagnosis of colonic obstruction.

Fig 550.— Typical jejunal shadow

a **Gas Shadows.**—When the jejunum, the ileum, or the colon is distended with gas each has a characteristic appearance that allows it to be distinguished radiologically. Obstruction of the small intestine is revealed by relatively straight loops that generally lie transversely in a step-ladder fashion across the abdomen that of the colon is disclosed by its haustral markings, while a distended cæcum is shown by a rounded blob of gas.

Jejunum is characterized by its valvulæ conniventes that pass from the antimesenteric to the mesenteric border as spiral or watch-spring curved wide lines, spaced quite regularly giving rise to a concertina effect (*Fig* 550) which is not obliterated even when the intestine is distended tremendously.

Ileum The distal ileum is described by Wangensteen as being characterless (*Fig* 551).

Large intestine (the cæcum excepted) shows haustral folds that are sometimes difficult to distinguish from jejunum. However haustral folds, unlike the valvulæ conniventes,

[1] If the intestine is gangrenous it is better to resect without permitting the toxic contents to escape into the collapsed intestine below the obstruction, and there to be absorbed quickly

do not usually traverse the complete width of the bowel They are spaced irregularly and the indentations are not placed opposite one another on the mesenteric and the antimesenteric border (*Fig* 532) In obstruction of the large intestine gas is not *seen in the small intestine* unless the obstruction is of some standing and the ileocæcal *valve is incompetent* which is the case in no less than 30 per cent of cases.

Fig 531 —Typical ileal shadow

Fig 532.—Typical colonic shadow (*After W W Sands.*)

2 **Fluid Levels.**—In infants under the age of 2 years a few fluid levels of the small intestine are of normal occurrence. In the adult normally two fluid levels are sometimes seen, and must be regarded as physiological. One is at the duodenal cap. The other is seen but rarely it is a fluid level within the terminal ileum

In intestinal obstruction it takes a little time for the gas to separate from the fluid consequently fluid levels appear later than gas shadows. When dilatation of the intestine has occurred fluid levels become more conspicuous and more numerous by the time fluid levels are well marked the obstruction is in an advanced stage The number of fluid levels is proportionate to the degree of obstruction and to its site in the small intestine. The nearer the obstruction is to the ileocæcal valve, the greater the number of fluid levels (*Fig* 533) Obstruction low in the colon does not commonly give rise to fluid levels in the small intestine. The *commonest cause of false fluid levels is an incompletely* evacuated enema.

Fig 533.—Multiple horizontal fluid levels. Subacute intestinal obstruction by a band. (*A J Lea.*)

In obstruction of increasing duration, the ratio of gaseous to fluid contents decreases, until there may be *virtually no gas apparent at the end of seven or eight days.*

The coffee-bean sign of a strangulated coil is characteristic, but *unfortunately it is only demonstrated occasionally*

Other characteristic radiological appearances will be referred to in special forms of intestinal obstruction, which will be described presently

THE EARLY DIAGNOSIS OF INTESTINAL OBSTRUCTION

Whether it is the strangulating or the non strangulating variety early diagnosis of intestinal obstruction is the hand maiden of successful treatment. Usually the diagnosis can be made without radiological assistance which, although most desirable is not essential. Positive radiological evidence is confirmatory negative evidence is without value. Acute obstruction of the small intestine is more difficult to diagnose early than obstruction of the large intestine.

Pain If the obstruction lies in the jejunum, or high in the ileum the characteristic attacks of intestinal colic come on at intervals of from three to five minutes. In obstruction to the terminal ileum or the large intestine the intervals of freedom are longer—from six to ten minutes.

Borborygmi: The co-existence of intestinal colic and borborygmi heard with the aid of a stethoscope establishes the diagnosis in 9 out of 10 cases.

Vomiting Retrograde peristalsis occurs, causing the stomach to eject bile, and later intestinal contents. The vomit begins to assume a fæcal character only after 3½ days of

complete obstruction. Vomiting due to obstruction of the jejunum or high in the ileum results in a tremendous loss of water, sodium and chlorides, and some potassium. Conversely obstruction of the terminal ileum or the large intestine is associated with relatively little severe loss of fluids and salts, for most of the secretions of the alimentary canal are re-sorbed for at least two or three days after the onset of obstruction situated in these regions.

Dehydration. The differences in the amount of fluid that normally pass a given level of the small intestine are surprising —

Duodenojejunal flexure (saliva, gastric juice, bile, pancreatic juice + ingested fluid)	8–10 litres
Mid-ileum	8 litres
Ileocæcal junction	½ litre

Therefore, it will be appreciated that dehydration is slow to develop in obstruction to the terminal ileum or the large intestine, whereas in obstruction of the jejunum dehydration often becomes overwhelming in two or three days.

Distension is progressively more in evidence in lower (as opposed to higher) intestinal obstruction.

Absolute Constipation. As the result of a second enema, no fæces and no flatus are passed. This test is very valuable, especially in the case of obstruction to the large intestine, but it should not be carried out until after the abdomen has been radiographed if that form of examination is available.

The rule that constipation is present in intestinal obstruction is broken in mesenteric vascular occlusion, Richter's hernia, and a pelvic abscess, all of which are liable to produce intestinal obstruction and also an irritative diarrhœa.

Preparation for Operation.—In the presence of intestinal distension up to 4 hours can be expended in decompressing the obstructed intestine by gastro-intestinal aspiration and improving the patient's general condition by intravenous fluid therapy before undertaking operation. Conversely, when a confident diagnosis of intestinal obstruction can be made really early before distension has occurred, or there is reason to believe that a loop of intestine is in danger of gangrene, e.g., strangulated hernia, as little time as possible should be lost in proceeding to operate.

An antibiotic régime is as follows —

1. Prophylactic penicillin and streptomycin should be given to all patients with intestinal obstruction.

2. Neomycin in an isotonic solution should be injected through the intestinal aspiration tube after decompression of the proximal bowel, in anticipation of possible intestinal resection.

LAPAROTOMY FOR INTESTINAL OBSTRUCTION OF UNCERTAIN ORIGIN

Instruments.—More instruments may be necessary than is the case for most urgent operations. A reasonable selection is depicted in *Fig. 554*. The surgeon should make a *point of reviewing the instruments and apparatus personally* to see that everything is there before commencing an operation for acute intestinal obstruction.

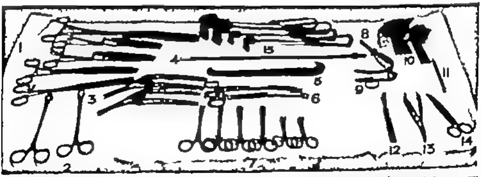

Fig. 554.—Instruments for operation for intestinal obstruction. The hæmostats are on a separate table. The needles and the needle-holder have been omitted for the sake of clearness. Four eyeless needles are put in to soak in order to ensure that the attached catgut is pliable. 1, Intestinal clamps; 2, Lane's tissue forceps; 3, Payr's crushing clamps; 4, Catheter (for enterostomy); 5, Sargent's depressor; 6, Moynihan's tetra forceps; 7, Towel clips; 8, Trocar and cannula; 9, Printy's needle-puller; 10, Paul's tubes; 11, Spigot; 12, Bard-Parker knife; 13, Jeans dissecting forceps; 14, Mayo's scissors; 15, Retractors.

The Incision.—The right lower paramedian incision is used, the rectus being mobilized and retracted outwards. A point above the linea semicircularis (semilunar fold of Douglas) is chosen for opening the peritoneum. The peritoneum must be incised with great care, for a distended loop may be just beneath. A warm, moist pack is in readiness to cover up any intestine that escapes.

The Search for the Cause of the Obstruction.—The first step is to inspect the cæcum. It is not sufficient to palpate it: it must be seen.

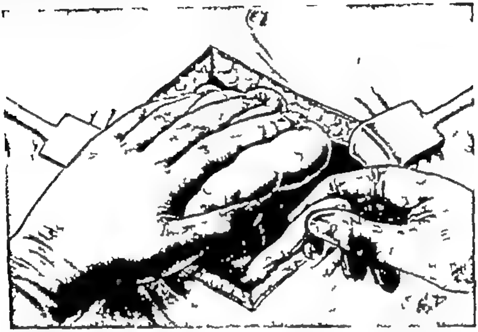

Fig. 555.—Intestinal obstruction of uncertain origin. Tracing a loop of *collapsed* intestine to the site of the trouble. (Towels omitted for the sake of clearness.)

If the cæcum is ballooned and tense, it is certain the obstruction is in the large gut. Palpate the upper rectum and sigmoid. If the cause of the obstruction is not there, trace round the colon, paying especial attention to the splenic and hepatic flexures.

If the cæcum is not distended, the obstruction lies in the small gut. Try and locate a loop of *collapsed* intestine and follow this to the point of obstruction (*Fig.* 555). When a collapsed loop of intestine cannot be found readily, explore the pelvis and the right iliac fossa. If the obstruction lies in the small intestine, the gut in the region of the ileocæcal valve *must* be distal to the obstruction.

When there is difficulty in finding the obstruction, *partial or subtotal evisceration* usually simplifies the search. While evisceration should only be practised when absolutely necessary, the procedure is not harmful, provided the intestines are covered with warm saline-soaked towels. To the assistant and instrument nurse are relegated the duties of making sure that all prolapsed intestine is covered up, and that towels are changed as soon as they become cool.

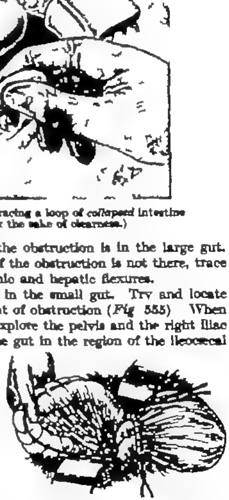

Fig. 556.—Lahey's rubber bag for accommodating eviscerated coils of intestine.

A better method is to employ a Lahey bag (*Fig.* 556). The bag is made of rubber thick enough to retain heat. It is provided with double draw-strings at the open end. Its use aids exposure tremendously, and with the minimum loss of heat and irritation of its peritoneal coat that are liable to accompany evisceration.

INTUBATION AT OPERATION

If time and facilities for passing a Miller Abbott or similar tube pre-operatively are lacking, it should be recalled that it is sometimes possible to manipulate the tube through the pylorus at the time of operation. If it seems likely that this manœuvre would entail much expenditure of time, or undue intra-abdominal manipulation, no hesitation should

arise as to the wisdom of performing open prepyloric intubation (*see* p. 200) through a separate small incision directly over the pylorus.

EMPTYING DISTENDED INTESTINE AT OPERATION[1]

Gastro-intestinal aspiration has rendered the necessity for this step less frequent. The procedure should be resorted to only in exceptional circumstances.

The indications for emptying distended intestine are —

1. If the distension is too great for the obstruction to be found.
2. When the distension is so great that it is improbable that the abdominal wall can be repaired without undue trauma and waste of time.

Emptying the intestine at operation should always be avoided if possible. Unless the bowel is handled with the greatest gentleness it may subsequently become paralysed

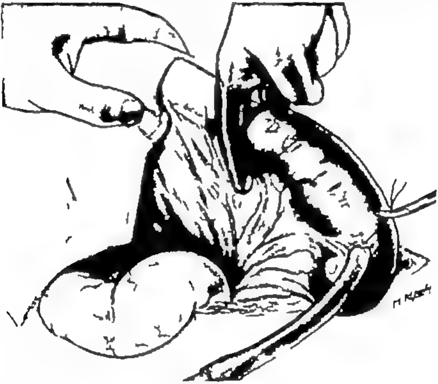

Fig. 337.—Emptying distended small intestine. The surgeon's fingers are dipped in liquid paraffin. (*After W. B. Holden.*)

or perforated. There is sometimes another disappointing sequel: at first the patient seems to be fairly well but some hours later shock comes on suddenly as a result of absorption of toxins from the intestinal wall when the circulation becomes fully restored.

Holden's Method.—About 6 in. (15 cm.) of a dilated loop of intestine are emptied and rubber-covered clamps are applied above and below. After most carefully isolating the loop with packs, a No. 32 de Pezzer catheter with its eyelets enlarged is introduced through an appropriate incision in the convex border of the empty loop. Two rows of purse-string sutures ensure a watertight junction. A hot moist abdominal pack is arranged about the catheter. The clamps are removed. If the surgeon is not quite certain that his gloves are unsoiled, he should certainly change them before proceeding to the next step, which consists in stripping the intestinal contents towards the catheter in order that they may be evacuated (*Fig.* 337).

Gentleness is the keynote of success, and only sufficient contents should be evacuated by manipulation to achieve the desired end, i.e., to demonstrate the obstructing agent or to deflate the intestine sufficiently to allow the abdomen to be closed.

[1] If this expedient must be resorted to, an intravenous antibiotic and an intramuscular injection of anti-gas-gangrene serum should be given on the operating table.

As this method is only employed in cases of dire necessity it will be a good practice to leave the de Pezzer catheter in situ to serve as an ileostomy If possible reinforce the area of the purse-string with a flap of omentum.

Method of emptying the Intestine with a Mechanical Sucker.—When mechanical suction is available another (and better) method can be employed. A distended coil near the point of obstruction is emptied by stripping gently using the fingers. Intestinal clamps are applied. A purse string suture is placed. An opening into the lumen is made in the centre of the encircled area and an ordinary suction tip is inserted and the suture is tied. The clamps are removed. Low pressure suction is commenced, and as the bowel collapses most of it is threaded on to the 6–8 in. (15–20 cm.) of the suction tube By gentle manipulations about 6–8 ft (1 8–2·4 m.) of bowel can be emptied. Distended coils are straightened and their fluid and gas content guided towards the suction. When the suction is completed enterostomy can if thought desirable be established through the same opening Appropriate steps are then taken to relieve the obstruction.

ANASTOMOSIS OF A DILATED LOOP WITH A COLLAPSED LOOP

In complicated obstruction when the condition of the patient will not permit the operation being prolonged beyond the bare minimum of time anastomosis of a conveniently placed dilated loop with an obviously collapsed loop has many times proved to be a means of saving life.

E. R., aged 30 four years previously had acute appendicitis with drainage. One year previously his abdomen was opened at the forty-eighth hour for acute intestinal obstruction by a band. On this second occasion he was admitted with typical intestinal obstruction of four days duration, and his general condition was poor After two hours of preparatory treatment a left paramedian incision (to avoid the scar tissue of previous operations) was made The interior was a mass of adhesions. Some of these were separated, but the main trouble seemed to lie where the gut was adherent to the abdominal wall. His condition was so poor that it was imperative to finish the operation as quickly as possible. A collapsed and obviously contracted loop was anastomosed to a dilated loop. Recovery

This patient was kept under observation for two years. Every few months he had an attack of severe abdominal pain which usually passed off in a few hours After an unusually severe bout further operative treatment was advised. Through an upper abdominal incision the small intestine was run through the fingers until the obstructed area was reached. The ileum was then divided completely at a convenient point and after closing the ends lateral ileotransverse colostomy was performed. The result was perfectly satisfactory

P W., aged 27 was seized with severe epigastric pain forty-eight hours before admission. Soon after the attack had started he was given a Seidlitz powder this increased the pain which passed to the lower abdomen. He had vomited at least twenty times. On examination the abdomen was greatly distended. The scar of a right, lower paramedian incision bespoke of appendicectomy for purulent appendicitis performed twenty years previously The pulse was 90 and the temperature subnormal A plain radiograph taken *en route* to the ward showed fluid levels.

After suitable preparation with gastric aspiration and continuous intravenous dextrose-saline solution for half an hour under spinal anaesthesia a central midline laparotomy was performed, the umbilicus being excised. In passing it will interest the reader to note that this incision (*Fig* 538) which was employed in order to avoid the old scar proved a most happy choice. Coils of small intestine the size of a bicycle tyre made location of the obstructing agent difficult. A few coils were exteriorized and wrapped in warm saline-soaked abdominal packs, enabling a loop of collapsed small intestine to be found. Further loops of distended gut had to be withdrawn before the site of the obstruction could be visualized. It was then discovered that the obstruction was due to acute angulation of the gut with adhesions to a solitary calcified tuberculous mesenteric lymph-node Lateral anastomosis was performed between the distended loop immediately above the obstruction, and a collapsed loop below Enterostomy was then carried out the enterostomy tube being brought out through a stab incision on the right-hand side of the laparotomy incision. The abdomen was closed with three through-and through nylon sutures and two stainless-steel sutures, and a continuous catgut suture was employed for the aponeurotic layer

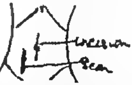

Fig. 538.—Facsimile of a diagram in the operation notes of the case of P W

For three days large quantities of semifaeculent fluid were withdrawn from the stomach, and no peristaltic sounds could be heard. The enterostomy which at first had discharged about ½ pint (280 ml.), ceased to act. By the fourth day the patient's condition began to deteriorate, and there

was still no evidence of discharge of fæces or flatus from the enterostomy tube or from the rectum after an enema. The pulse remained of fairly good volume, the rate being about 120. During the days that had elapsed since the operation, the fluid balance had been adjusted by dextrose-saline solution given intermittently through the venule described on p. 16.

Fig. 539.—P. W. The enterostomy scar is barely visible.

Before attempting to exchange the gastric aspiration tube for a Miller Abbott[1] tube the patient was given 1 pint (568 ml.) of protein hydrolysate intravenously and at the same time 4 oz. (114 G.) of magnesium sulphate were injected through the Nodman tube. At the conclusion of the administration of the amino-acids the patient said he felt much better although he complained of a sensation of being hot. A few hours later still, he had a spontaneous action of the bowels. The gastric aspiration tube was then withdrawn, and convalescence was uneventful.

The enterostomy tube was expelled on the tenth day. No leakage occurred. Thanks to a watershed dressing (*see* p. 433), the laparotomy wound healed by first intention.

The patient returned to work, and remained quite well (*Fig.* 539).

Ileostomy.—*See* p. 526.

Extraperitoneal End-to-side Anastomosis.—Probably a better choice of operation in a desperately ill patient with advanced non-strangulating obstruction of the lower ileum that cannot be relieved easily is to perform extraperitoneal end-to-side intestinal anastomosis with terminal enterostomy (*see* p. 404). This gives most of the highly toxic obstructed intestinal contents a free exit, and spares the toxic products from being absorbed by healthy intestine below the obstruction.

DETERMINING VIABILITY OF GUT

Because this problem most often occurs in connexion with bowel strangulated in an external hernia, it is considered fully in the appropriate chapter. Nevertheless, everything is to be gained by reiterating a most practical and frequently required procedure.

One of the most delicate tests for viability of gut is the observance of a change in colour of the bowel concomitant with the inhalation of 100 per cent oxygen. The early change of colour to a bright pink manifests when blood is circulating through the damaged segment, and viability is assured. Oxygen not only causes a change in colour but it also accelerates the recovery of a doubtful portion of gut.

When the administration of pure oxygen fails to render the portion of intestine under observation a bright pink, resection must be carried out.

THE RECOGNITION OF NON-VIABLE INTESTINE

	VIABLE	NON-VIABLE
Colour	Red→dark purple	Black→green
Mesentery	Œdematous, but arterial pulsations can be felt No thrombosis	No pulsation. Thrombosis
Visceral peritoneum	Sheen present	Lustreless
Response to towels wrung in warm saline solution and administration of oxygen	Colour bright red Peristalsis	Colour alters but little Still no pulsation No peristalsis

Unless the condition of the patient is extremely poor, when exteriorization offers a greater hope, gangrenous intestine must be resected and the continuity of the alimentary canal restored by one of the methods of anastomosis that have been described. If the affected portion is just viable but its extremities are marked by rings of former constriction which are non-viable, resection of the whole coil should be carried out.

[1] The patient was in a hospital without a resident medical officer or a portable X-ray apparatus. This is a consideration when coming to a decision whether to attempt transnasal intestinal aspiration or not.

The risk of subsequent gangrene of plum-coloured intestine that does not alter in colour on the administration of oxygen is greater if the segment involved is 20 in. (50 cm.) or more in length consequently if the segment thus affected is long it should be resected

STRANGULATION OF THE LARGE INTESTINE

Strangulation of the large intestine is comparatively rare. Its management differs from that of the small intestine in two cardinal particulars (1) Primary anastomosis after resection in the presence of acute intestinal obstruction must never be undertaken Through a separate lower abdominal incision the non-viable segment is exteriorized. When possible a Paul-Mikulicz procedure (see p. 433) is undertaken before the gangrenous portion is excised (2) Invagination of a gangrenous patch or doubtful constriction marks is not safe because of the degree of distension that commonly occurs in the post-operative period In either of these contingencies resection of the involved portion must be carried out

The exception to this rule is gangrene of the caecum, where exteriorization without resection but with caecostomy is safe

SOME PRINCIPLES IN THE AFTER TREATMENT OF INTESTINAL OBSTRUCTION

Intestinal aspiration should be continued until the patient passes flatus per rectum. Intravenous fluid therapy is also continued as long as deemed necessary—usually for 24 hours after the patient has passed flatus. Blood transfusion is always required in patients who have undergone resection.

During the post-operative period, in cases where resection of gut has been performed neomycin in an isotonic solution may be added to the irrigating solutions used to clear the intestinal aspiration tube. This solution, used every one or two hours in the post operative period with intermittent interruption of suction will maintain a continuous concentration of the drug within the bowel.

The frequency with which lethal pulmonary embolus occurs during convalescence of patients with relieved acute intestinal obstruction suggests that anticoagulant therapy is advisable after serious abdominal distension. Absolute rest in bed during the course of suction-decompression should be avoided, especially in elderly patients. Actually ambulation appears to aid the descent of the tube.

CLASSIFICATION OF ACUTE INTESTINAL OBSTRUCTION

Acute and acute on chronic intestinal obstruction is a large and difficult subject upon which to write After due consideration it has been decided to divide it into (1) Obstruction to the small intestine p. 422 (2) Obstruction to the large intestine p 442 (3) Paralytic ileus, p. 462 (4) Intestinal obstruction in the newborn, p. 466 (5) Intussusception, p. 480 and (6) Obstructed and strangulated herniae, p. 496.

It is considered that the subjects so arranged will prove convenient for study and reference.

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CHAPTER XXXIII

ACUTE OBSTRUCTION OF THE SMALL INTESTINE

POST-OPERATIVE BANDS AND ADHESIONS

While any abdominal operation may be responsible an overwhelming majority of cases of post-operative intestinal obstruction follow gynaecological operations and operations for acute appendicitis. In 99 per cent of cases it is the small intestine that becomes obstructed by post-operative adhesions. Of all the causes of intestinal obstruction, whether of the large or the small intestine, the commonest (barring only obstructed and strangulated external herniæ) is post-operative bands and adhesions, which constitute 41 per cent of all cases.

Post-operative bands and adhesions are divided into: *Recent*—those occurring while the patient is in hospital or at a convalescent home recovering from an abdominal operation and *Remote*—those occurring at any time after the patient has returned home.

RECENT POST-OPERATIVE OBSTRUCTION

When obstruction is due to generalized adhesions (*Fig* 560F) the onset of symptoms is variable. When it is due to a localized adhesion (*Fig* 560C) the symptoms commence between the second and seventh post-operative days, as also when a knuckle of intestine herniates through a hiatus in the stitched pelvic peritoneum (*Fig* 560B). When the cause

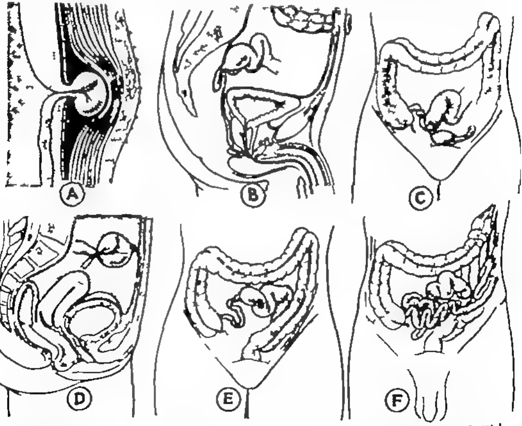


Fig 560.—Ways in which post-operative intestinal obstruction can occur (A) Partial wound disruption; (B) Herniation through the pelvic floor (the rectum has been removed); (C) Localized adhesion to the site of operation; (D) Adhesion causing volvulus; (E) Cicatricial contraction following end-to-end anastomosis; (F) Generalized adhesions due to peritonitis. (*Figured by G. L. Kratter*.)

is partial wound disruption (*Fig* 560A) symptoms of obstruction become apparent between the sixth and ninth post-operative days; it may be a day or two later before the tell tale serosanguineous fluid appears on the dressing

The diagnosis of early post-operative obstruction is often particularly difficult. In the first place during the first three or four days following an abdominal operation, almost every patient passes through a phase of intestinal disturbance, the signs of which are vomiting gas pains and/or abdominal distension. In a few these untoward symptoms progress until the patient is rendered seriously ill For this reason, until it is proved otherwise, it is well to regard every patient who has had a major abdominal operation as being one of the unlucky few

In the second place physical signs of the abdomen are modified by a recent incision in its wall for instance, tenderness of the wound may mask deep tenderness. Nevertheless, when intestinal obstruction is present, distension as shown by measurement, turbulent borborygmi[1] elicited with a stethoscope and occasionally visible peristalsis, can be discerned if time-consuming care is taken to search for them.

Although it is not infallible, *radiography* is of signal service in post-operative obstruction it is the small intestine that contains gas (*Fig* 561) whereas little or no gas is present in the cæcum or the colon. Should partial wound disruption be suspected, sometimes a lateral radiograph will reveal a distended loop in the abdominal wall. If facilities exist the frequent use of X ray films interpreted by a skilled radiologist are a valuable aid in the differential diagnosis between mechanical intestinal obstruction and paralytic ileus. The crucial radiological findings of obstruction of the small intestine are the presence of distended coils, together with the absence of any gas in the large intestine.

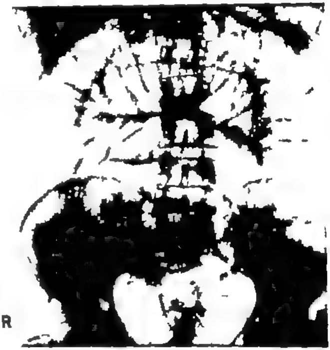


Fig. 561 —Intestinal obstruction following acute appendicitis with pelvic peritonitis. (*M H J pe.*)

When this differential diagnosis is unsettled, a period from four to twenty four hours of intestinal aspiration will improve the patient's condition, but unless he passes flatus per rectum, or it can be shown radiologically that gas has passed from the small into the large intestine those in attendance may be lulled into a state of confident serenity until *worsening* of the patient's condition, often sudden shatters their limitless faith in intestinal intubation.

The patient must be examined at least at four hourly intervals. If the diagnosis is in doubt apply the following test If the tube is clipped and suction discontinued for two hours, does rhythmic abdominal pain return? If the answer is in the affirmative the patient's small intestine is obstructed and positive radiological evidence though desirable becomes redundant.

During this anxious period the possible causes of post-operative intestinal obstruction (*Fig* 300) should be mentally visualized, with particular thought as to which is applicable to the case under review It is highly important to be aware of the fact that 10 per cent of cases of recent post-operative intestinal obstruction are of the strangulating variety

Treatment.—In the great majority of instances a patient with *obstruction by multiple adhesions due to infective peritonitis* can be treated safely and effectively by non-operative measures. As a rule continuous aspiration through an intestinal tube permits resolution

[1] *Borborygmus.* Any intestinal sound due to flatus, whether it is produced in normal or abnormal circumstances.

of the inflammatory process, and favours diminution of oedema of the bowel wall, so that early resumption of intestinal function occurs. On the other hand, even in this group, conservative treatment must be continued with great caution. Unless evidence of recovery is prompt and unequivocal, operation is required. In too many instances, after putting implicit faith in suction drainage for too long without testing its efficacy (see the twin test above), operation has to be performed on a prostrate gravely ill patient.

Operation for Recent Post-operative Intestinal Obstruction.—Except in the case of suspected deep disruption of the wound, it is far better to make a fresh incision, often a lower left paramedian incision. The cause of the obstruction having been found, not infrequently it can be remedied by the simplest of all abdominal operations—gently breaking an adhesion with the finger The affected coil is then withdrawn and examined often the contracted empty intestine immediately below the point of obstruction can be seen to fill—a very pleasing sight. If it is available, the great omentum should be laid over the roughened, oozing area on the intestinal wall. The rule quick in, quick out is only broken in the case of obstruction at the site of an end to-end anastomosis, when anastomosis of an obviously distended with an obviously contracted loop has to be performed. Unless a Miller Abbott or similar tube is already within the small intestine, supplementary enterostomy is a sound measure in advanced cases.

At this juncture it will be profitable to consider in greater detail —

RECENT INTESTINAL OBSTRUCTION FOLLOWING ACUTE APPENDICITIS

Obstruction following operation for appendicitis rivals general peritonitis as the most lethal complication of the disease. It is to some extent preventable, for its incidence is considerably reduced by adopting the Ochsner Sherren method of treatment (see p. 222) in selected cases of acute appendicitis arriving too late for early operation. Preventable, too since obstruction may be an aftermath of imperfect technique in the matter of removing the appendix or in the insertion and management of a drainage tube.

Obstruction is most frequent between the sixth and tenth day after appendicectomy Realizing this, it is an excellent practice for the surgeon to make a habit of writing on the notes of a patient in whom intestinal obstruction is a possible development: "Watch for intestinal obstruction particularly between the sixth and tenth days." Notes of the original operation made by the operator himself, are especially valuable in visualizing the nature of the obstruction. An accurate mental picture of the obstructing agent is the surest help in carrying out appropriate treatment.

Three types of recent post-appendicular obstruction can be recognized, each requiring different treatment.

Type 1—Recent obstruction by an adhesion may occur after any operation for removal of an acutely inflamed appendix. It is, however more prone to follow a certain type of case namely at the original operation the appendix was found occupying a pelvic position in contact with small intestine a few bread-and butter like adhesions were in the vicinity but there was little peritonitis. Signs and symptoms are often particularly elusive. The patient who has been going on perfectly well, suddenly complains of intestinal colic, and vomits, usually between the sixth and tenth day after operation. These symptoms in the type of case delineated above are sufficient to warrant opening the abdomen. No form of intestinal obstruction is more urgent, and in no form of intestinal obstruction are physical signs less in evidence.

While walking through the ward I noticed a child vomiting An acutely inflamed appendix had been removed nine days previously and her condition had given no cause for anxiety in the mean time She stated that she had had pain that afternoon. The pulse and temperature were normal, the bowels had been opened that day and there were no physical signs. Operation was advised and on opening the abdomen a coil of ballooned intestine was found to be angulated by being adherent to the abdominal wall at one point. The acute obstruction was remedied by breaking an adhesion.

This favourable result was the outcome of a determined effort to get the next case of intestinal obstruction following appendicectomy for acute appendicitis early The argument is this If a patient who has been convalescing normally until the sixth to tenth day and has given no cause for anxiety experiences sudden pain and vomits, it is highly probable that intestinal obstruction is the cause Furthermore the danger of opening the abdomen of a patient in good condition is infinitely less than waiting until the diagnosis is more assured.

Type 2 is almost the antithesis of the foregoing. The patient from the very start gives rise to anxiety for he is distended from peritonitis. The riddle to be answered is: "Are the symptoms due to paralytic ileus or to mechanical obstruction?" Almost without exception during the first three days after the operation obstructive symptoms are due to paralytic ileus (*see* p. 402). After this time it is probable that plastic peritonitis has given rise to multiple kinks and adhesions with which the enfeebled peristaltic waves are unable to contend. The patient is desperately ill. This is an occasion where the balloon tipped intestinal aspiration tube is likely to succeed in bringing about restitution of intestinal function. In the absence of such a tube or failure to pass it or where the symptoms recommence after suction aspiration has been discontinued, enterostomy is indicated, and I can recall several instances where enterostomy under local anaesthesia has saved the patient's life.

Type 3.—From our knowledge of the case we picture within the abdomen a length of diseased ileum adherent and impossible to free without a severe operation. Under such circumstances an operation designed to remedy the obstruction too often terminates in an unavoidable resection, for the distended gut is very friable. This type of obstruction is liable to occur after severe pelvic peritonitis. The state of affairs can be appreciated by referring to Sampson Handley's illustration of ileus duplex (*Fig.* 362).

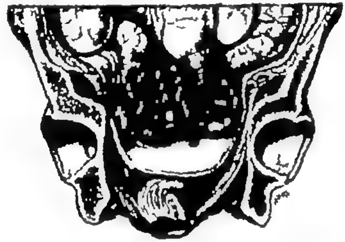


Fig. 362.—Ileus duplex arising from gangrenous pelvic appendicitis. (*Sampson Handley.*) (*British Journal of Surgery.*)

If on thinking over the case one has good reason to believe that within the peritoneal cavity there exists a form of obstruction such as has been portrayed above or alternatively if such a condition of compound obstruction has been found on exploratory laparotomy then, unless the patient's condition is desperate when ileostomy offers the only hope the following form of treatment is recommended.

Through a supra-umbilical midline incision a coil of jejunum is withdrawn. *If neighbouring gut is free from peritonitis*, we run the small intestine through our fingers until the commencement of the diseased area is reached. If the great omentum is well developed, a hole is made in it near its attachment to the transverse colon and the selected coil is brought through. If the great omentum is poorly developed, this step is omitted. Then, using clamps, ileocolostomy is performed either by lateral anastomosis or what is perhaps better by the Maylard-Sonnenberg technique (*see* p. 434).

Ileotransverse colostomy in the type of case described has saved many lives. The operation is performed through an unscarred area; the gut is free; the operation is a set one and should occupy a definite period of time which can be judged beforehand. It may also be of service in cases properly belonging to *Type* 1 where the obstruction has recurred more than once.

REMOTE POST-OPERATIVE OBSTRUCTION

Remote post-operative obstruction occurs much more frequently than recent post operative obstruction.

Obstruction by a Band.—There are occasions—happily frequent occasions—where the band is nothing more than a string of avascular fibrous tissue. Even so it is most advisable

to display the whole extent of the obstructing agent (*Fig* 363) and sever it under vision. Such a step is imperative if by touch and incomplete visualization the exact nature of the constricting agent is doubtful. As a rule it is advisable to deliver the coil or coils, suitably protect them with warm moist packs, and then to pass a director under the constricting agent but not to sever it until one is satisfied that simple division is all that is required. The two narrow areas of intestine constricted by a tight band require careful scrutiny. If either or both markings persist (it is usually the proximal line of constriction which has borne the brunt of the obstruction that is of doubtful viability) it is highly important to invaginate it. A cord-like band should always be sectioned between ligatures; such adhesions are often remarkably vascular. Also, as Stephen Power emphasizes, an adhesion may cone-out the intestinal wall (*Fig* 364); it should therefore always be severed some distance from the intestine.

Fig 363.—Obstruction by a band of adhesions.

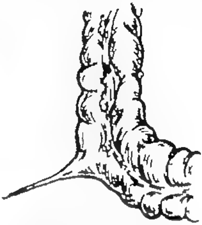


Fig. 364.—An adhesion drawing out a portion of the intestinal wall. To show the necessity for dividing adhesions at some distance from the gut. (*After Stephen Power.*)

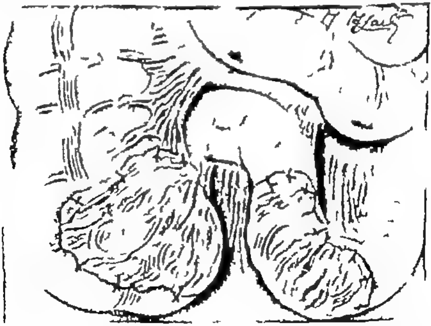


Fig 365.—The raw areas have been covered by free omental patches.

Obstruction by Adhesions.—On occasions the separation of localized adhesions by sharp dissection obviously remedies acute intestinal obstruction. Clean sharp dissection produces far less liability to the formation of fresh adhesions than blunt dissection. When time permits, the raw areas should be covered by omental grafting, thus minimizing re-adherence of the raw surfaces and renewed obstruction at a later date. A typical example is illustrated in *Fig.* 303.

The Problem of Recurring Attacks of Intestinal Obstruction, usually an aftermath of peritonitis, has to a large extent been solved by Noble's plication operation (*Fig.* 306). If a patient has had two or more attacks of intestinal obstruction due to adhesions, necessitating operation for its relief, the arguments in favour of performing a plication operation are weighty. The operation must always be performed *as froid* about six weeks or two months after the last urgent operation.

A detailed description of this operation is beyond the scope of this work.

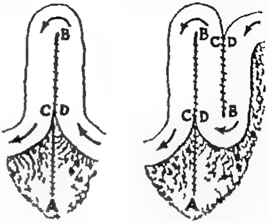


Fig. 366. —Noble's operation. Adjacent coils (average length 6–8 in. (15–20 cm.)) are sutured together along their mesenteric borders. The resulting folds of mesentery are also united.

OBSTRUCTION BY ANGULATION

Obstruction by angulation can occur in a number of ways. By far the most frequent is when a portion of the intestinal wall becomes adherent to a caseating tuberculous lymph-node in the mesentery of an adjacent loop (*Fig.* 367). This is a cause of obstruction of the small gut so often that some details concerning it are necessary. In comparatively early cases where the area of adherence is not more than half an inch (1·25 cm.) in diameter the intestine can be dissected free. It is impossible to foretell whether or not the intestinal wall is virtually perforated at the point of adherence. In order to obviate the catastrophe of an unexpected gush of fæcal fluid it is essential to apply an intestinal clamp and to pack off the area carefully before separation is commenced. Having freed the loop, if perforation exists, it is closed. In any case, to patch the area with a free omental graft is a wise precaution. It is also recommended to patch the raw area in the neighbourhood of the caseating lymph node. While this is being done great care must be taken not to occlude the blood-supply to the related gut.

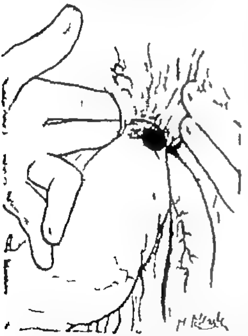


Fig. 367.—Obstruction by angulation of the intestine. A loop of intestine has become adherent to a caseating tuberculous lymph-node.

When a loop of intestine is adherent over a wide area, or the points of adherence are multiple, and particularly when the patient's condition is unsatisfactory, here is an occasion *par excellence* for anastomosis between the distended intestine a short distance above, and the collapsed intestine a short distance *below* the obstructed area.

VOLVULUS OF THE SMALL INTESTINE

A large part of the small intestine may be involved (*Fig.* 368). This is the common variety in Africans. Kerr and Kirkaldy-Willis report 7 cases occurring at the Native Civil Hospital, Nairobi, in a year. After effecting untwisting they found the distension was so great that it was impossible to return the gut to the abdominal cavity without

emptying it. In several cases Holden's method (*see Fig 557* p. 418) proved unsatisfactory because the rubber tube became blocked with maize grains and other vegetable material. It was therefore necessary to remove the tube and empty the gut directly through the incision in the intestine. Six out of the seven patients recovered.

Fig 568.—Volvulus of a large part of the small intestine.

The more usual variety encountered in Britain is volvulus of a limited segment of the intestine, rarely more than 2 or 3 ft. (60 or 90 cm.). A band of adhesions is often the predisposing cause, and unhappily frequently the gut is gangrenous by the time the patient reaches surgical aid.

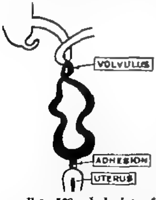


Fig. 569.—Volvulus of the lower ileum. An apical adhesion was the starting point of the intestinal rotation in this case.

A married woman, aged 37, was admitted on Christmas Day. Except for an indefinite history of indigestion, she had enjoyed normal health until Dec. 21, when she was seized with epigastric pain and vomiting. For four days the pain and vomiting had continued, and there had been absolute constipation. On examination, the abdomen was drumlike. Her general condition was poor. The pulse was 120 and thready, but the patient mentally was alert. A diagnosis of general peritonitis was made. On opening the abdomen, dark, reddish-brown, evil-smelling fluid escaped, and coils of jet-black small intestine were seen in the pelvis. On further examination the condition shown in *Fig* 569 was found. Resection. Ileocæcostomy. Drainage of the peritoneum. The patient died the next day.

An omnibus conductor, aged 24, had acute appendicitis with general peritonitis. The appendix was removed, and the peritoneal cavity was drained. A month later, on the day upon which the patient was to have gone to a convalescent home, he was seized with acute lower abdominal pain, and vomited twice. Within two hours of the onset the abdomen was opened on a diagnosis of intestinal obstruction. A volvulus consisting of about 3 ft. (90 cm.) of the lower ileum was found. The gut was dark purple, its mesentery being very acutely twisted. Untwisting was carried out easily and after the application of hot saline packs the colour of the gut improved. The abdomen was closed. The patient recovered.

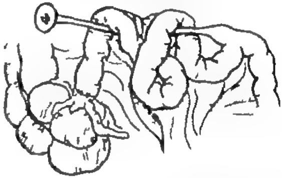
When resection is necessary it is highly important to include doubtful discoloured mesentery. Should non-viable mesentery be left behind, the patient will die of postoperative peritonitis. *See also* VOLVULUS NEONATORUM (p. 473).

OBSTRUCTION DUE TO MECKEL'S DIVERTICULUM

This embryological structure and its omphalomesenteric duct has many times been responsible for the occurrence of intestinal obstruction in otherwise perfectly healthy and often young subjects. The obstruction is produced in a number of ways the chief of these may be briefly enumerated as follows :—

1 It may cause a volvulus. ——→

2. Its omphalomesenteric duct causes a band under or over which a loop of intestine becomes snared. This is probably the commonest variety ——→



Suspecting that a band producing obstruction was an embryological remnant, I sent a piece of it for microscopical scrutiny which showed clearly the tubular interior The practical application of this knowledge is that bands should not only be divided, but clamped ligatured, and, if possible, buried.

3. The end of the diverticulum becomes attached to the mesentery and thereby kinks the ileum. ——→

4 Production of knot formation around the gut. ——→

5 The diverticulum becomes inverted and gives rise to intussusception (*see* p. 488).

There are no explicit instructions for treating a case of obstruction due to a Meckelian remnant, owing to the great variety of modes by which the obstruction can be produced. Each variety must be treated on its merits. Whenever the condition of the patient allows, the diverticulum should be crushed about a quarter of an inch (6 mm.) from its base and removed The stump being closed, the suture line may be reinforced by a free omental graft.

RETROPERITONEAL FOSSÆ

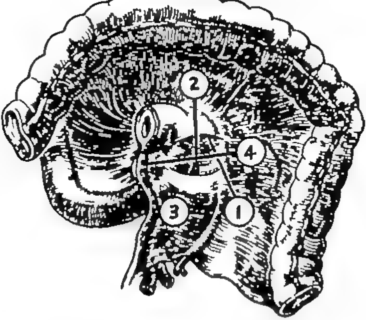


Fig. 570.—Fossæ around the duodenojejunal flexure. 1, Superior duodenal fossa; 2, Inferior duodenal fossa; 3, Left duodenojejunal fossa; 4, Right duodenojejunal fossa. (*Rodney Smith.*)

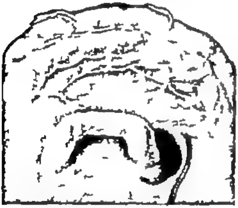


Fig. 571.—Left duodenojejunal fossa. The inferior mesenteric vein lies in its free border. (*After Rendle Short.*)

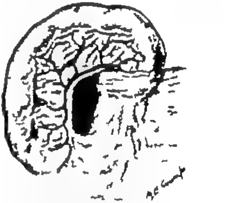


Fig. 572.—The right duodenojejunal fossa. The superior mesenteric artery lies in its free border. (*After Rendle Short.*)

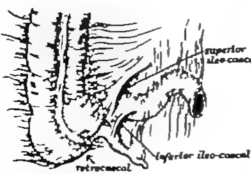


Fig. 573.—Peritoneal fossæ round the cæcum and appendix.

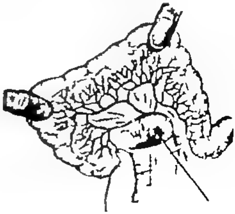


Fig. 574.—The intersigmoid fossa. (*After Jonnesco.*)

RETROPERITONEAL HERNIÆ

Admittedly herniation into a retroperitoneal fossa is exceptional nevertheless an emergency surgeon cannot afford to be unpossessed of a knowledge of the anatomy of the retroperitoneal fossæ. Those of surgical importance are —

The Left Duodenojejunal Fossa (*Fig* 570) —Lies to the left of the fourth part of the duodenum. Its mouth looks to the right *The inferior mesenteric vein lies in its free border* (*Fig* 571)

The Right Duodenojejunal Fossa.—Lies in the mesentery of the very commencement of the jejunum, below the duodenum. Its mouth looks to the right. *The superior mesenteric artery runs in its free edge* (*Fig* 572).

The Foramen of Winslow —Is bounded in front by the free border of the gastrohepatic omentum, with the common bile-duct hepatic artery and portal vein between its two layers behind by the peritoneum covering the inferior vena cava above by the peritoneum on the caudate lobe of the liver and below by the peritoneum covering the commencement of the duodenum and the hepatic artery

The Superior Ileocæcal Fossa lies between the general mesentery and a fold of peritoneum raised by the anterior terminal branch of the ileocolic artery

The Inferior Ileocæcal Fossa lies between the bloodless fold of Treves and the meso-appendix.

The Retrocæcal Fossa.—Lies behind the cæcum. Its mouth looks down.

The Intersigmoid Fossa is sometimes present on the left side of the pelvic mesocolon, and situated between the *anastomoses of the sigmoid artery* In the floor of the fossa lies the ureter Its mouth looks downwards (*Fig* 574)

Fig 578 —Strangulated left duodenojejunal hernia. (*After Masson and McIndoe.*)

Diagnosis.—In the case of any of the internal herniæ it is creditable to make a diagnosis of acute intestinal obstruction of the small intestine If the patient s abdomen is bereft of an operational scar and he has no evidence of an external hernia moreover if in addition he is young or in the prime of life it is permissible to add possibly due to an internal hernia In a proportion of cases an indefinite lump can be felt In some cases radiographic evidence favours an internal hernia, although much the same appearance is presented by a volvulus of the small intestine

Treatment.—Strangulation is as common in these cases as it is in external herniæ It is, therefore a great mistake to dally with intestinal suction drainage for more than the minimum of time needed to fit the patient for operation. Having opened the abdomen by a right paramedian incision centred at the umbilicus (unless there is some definite evidence that the obstruction lies in the upper or lower abdomen, when a more appropriate incision will be chosen) and having ascertained that an internal hernia (*Fig* 575) is present one proceeds in the same manner as in other cases of acute obstruction of the small intestine

The first question is Can the obstructing agent be divided ?

In the case of a left duodenojejunal hernia which, by the way is much the most common of the paraduodenal herniæ the answer is Yes If the division of the neck of the sac is done between hæmostats. Ordinarily it is quite safe to divide the inferior mesenteric vein (O H Wangensteen)

In the case of the right paraduodenal fossa the answer is a resounding No ; one must proceed as is shown in *Fig* 577

In the case of the foramen of Winslow (*the epiploic foramen*) to divide the neck of the sac would be an unpardonable crime

Occasionally stretching the mouth of the epiploic foramen serves to permit reduction of the herniated contents. The foramen can also be widened by the following procedure. Through a short transverse incision in the gastrohepatic omentum, just above the duodenum, the left index finger is insinuated and the hepatic artery and the portal vein are gently eased and hooked to the left. The right index finger is then introduced to retract the common bile-duct to the right. By reason of the laxity of the retroperitoneal tissues, this manœuvre enlarges the foramen, and usually allows the imprisoned contents to be withdrawn (Jeanbreu and Rich). If this method is unsuccessful—which is unusual—proceed as is shown in *Fig. 577*.

Coming now to herniation into one of the *fossæ around the cæcum and appendix*. All can be slit up with impunity except the superior ileocæcal fossa, which must be divided between hæmostats.

The same is true for the *intersigmoid fossa.*

The very first case of small-gut obstruction I was called upon to treat proved to be a hernia into the superior ileocæcal fossa.

A labourer, aged 46, thirty-six hours before admission had severe abdominal pain and vomiting. For years he had had indigestion and was a very heavy drinker. The temperature was 95° F. (35° C.) and the pulse 100. The skin was cold and clammy and the tongue dried and furred. He was a very fat man, which made abdominal examination difficult. There was general rigidity and some distension. On opening the abdomen, a large cystic swelling was felt. A hand passed into the pelvis brought up a lot of jelly which was lying free in the peritoneal cavity. A hole leading into the sac could be felt to the right of the sacral promontory. The peritoneal sac was slit up on a director, and a mass of distended small intestine escaped from the internal hernia. It was then apparent that a portion of the mesentery was bleeding furiously, and efforts to stay the hæmorrhage were unavailing. It was decided that this portion of the mesentery was gangrenous. Six inches (15 cm.) of intestine, including the bleeding mesentery, were therefore resected and side-to-side anastomosis was performed. Next day the patient was sitting up in bed and reading the paper. He said that he was very hungry and was free from pain, but the pulse was 132. It was one of those cases that are "too well" and which we learn to suspect. He collapsed and died twenty-four hours later. The post-mortem examination showed a satisfactory anastomosis. I suppose that death occurred from delayed shock.

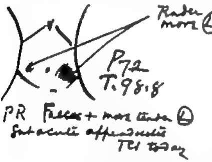


Fig. 576.—Facsimile of notes recorded in the case of R. J. M.

R. J. M., aged 18, was brought to the out-patient department. He stated that for two days he had had attacks of abdominal pain lasting up to one hour and that he had vomited several times. He further stated that he was now better. A facsimile of the clinical findings recorded in the notes is shown in *Fig. 576*. A few hours later the abdomen was opened through a gridiron incision. The appendix was removed and proved to be normal. As there was a considerable quantity of clear fluid in the peritoneal cavity the last 2 ft. (60 cm.) of the ileum were examined with a view to excluding the possibility of an inflamed Meckel's diverticulum. About 18 in. (45 cm.) from the ileocæcal valve withdrawal of the small intestine was impeded; therefore the incision was enlarged. It was then apparent that 1 ft. (30 cm.) of small intestine was entrapped in a paracæcal hernia. By gentle traction the coil was easily withdrawn. The patient made a smooth recovery.

STRANGULATION THROUGH A HOLE IN THE MESENTERY

It is most imprudent to cut the neck of the constricting ring, for not only will troublesome hæmorrhage occur, but the blood-supply to the overlying portion of the gut may be endangered.

The following method will be found effective:—

The convexity of the obstructed loop is encircled by a purse-string. A large-bore needle connected to an aspirating syringe is used to empty the loop (*Fig. 577*). The purse-string is then tied. The loop having been rendered flaccid, it will be found that it can be readily withdrawn.

After the gut has been examined and dealt with as occasion demands, the hole in the mesentery should be closed, or, as an alternative, a detached piece of omentum used as a plug.

Other strangulated internal herniæ through holes in the peritoneum require but brief mention. They are very rare and their treatment follows common-sense lines. They are —

1. Strangulation through a hole in the transverse mesocolon. Beware of the middle colic artery when enlarging the ring

2. Strangulation through a hole in the broad ligament

3. Strangulation through a hole in the falciform ligament of the liver I have encountered a case of this kind.

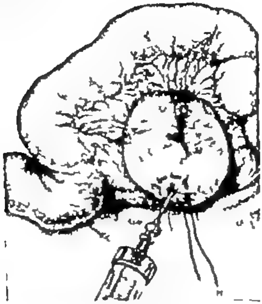


Fig 577 —Strangulation by a hole in the mesentery Emptying the obstructed loop before attempting reduction.

STRANGULATED SPIGELIAN HERNIA

Strangulated spigelian hernia occurs under a linea semicircularis (semilunar fold of Douglas) (*Fig* 578) and passes beneath that broad fascial band by which the internal oblique and transversalis muscles are inserted into the rectus sheath consequently it lies

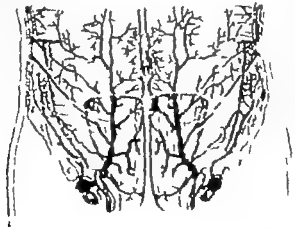


Fig 578.—The abdominal wall from the peritoneal aspect. Showing the lineæ semicirculares (the semilunar folds of Douglas) (*After Cullen.*)

under the aponeurosis of the external oblique The hernia has a tough, rigid neck and the sac is often covered by a considerable thickness of extraperitoneal fat. This, and the tense external oblique overlying it, makes it difficult to palpate. In a stout female to differentiate this condition from a twisted ovarian cyst or tearing of the inferior (deep) epigastric artery may be impossible

Watson and Scotter's case —

A stout woman, aged 63, developed sudden severe pain in the right iliac fossa. Slowly the pain travelled to the epigastrium then it became generalized and the most severe pain was constantly in the right iliac fossa. Vomiting commenced 12 hours after the onset and became very frequent and copious.

On admission the tenderness in the right iliac fossa was exquisite; she winced when the overlying skin was touched. A tense, oval swelling about 3 in. × 2 in. (7.5 × 5 cm.) was palpated in the right iliac fossa lying in the abdominal wall parallel to Poupart's ligament and 2½ in. above it. A diagnosis of strangulated spigelian hernia was made. An incision was made over the swelling. After the external oblique aponeurosis had been incised, the hernial sac was exposed. It contained strangulated loops of small intestine bound together by adhesions and omentum. After incising the rigid neck of the sac the congested intestine was found to be viable. Some of the adhesions were divided and the intestine returned to the abdomen. The layers of the abdominal wall were defined and the incision was repaired. Recovery.

OBSTRUCTED AND STRANGULATED DIAPHRAGMATIC HERNIA

Sir Astley Cooper first divided diaphragmatic herniæ into congenital (*Fig. 379*) and acquired, and the acquired into those that pass through points of anatomical weakness and those that are traumatic. This classification has never been improved upon. The hernia can be situated on either side or in the middle (hiatus hernia). The left side is much more common, both in congenital and traumatic cases.

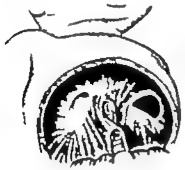


Fig. 379.—The foramen of Bochdalek.

Fig. 380.—Hernia through the left dome of the diaphragm. The liver has been removed. (*British Journal of Surgery.*)

All diaphragmatic herniæ can become obstructed, and in not a few of these the obstruction becomes strangulating. In a very high percentage of cases (some put it at over 70 per cent) the obstructed or strangulated hernia is traumatic. In order of frequency the following abdominal viscera have been found passing through the opening in the diaphragm into the thorax: (1) the stomach, or part thereof; (2) the greater omentum; (3) varying lengths of small intestine; (4) the transverse mesocolon; and (5) the ascending colon and cæcum. In S. Pearson's case only the spleen and descending colon were in the peritoneal cavity. A portion of the stomach is frequently involved in diaphragmatic herniæ of both traumatic and non-traumatic origin; strangulation is produced by rotation of the stomach on its long axis (*Fig. 380*). More than a dozen cases of gangrene of the stomach or a part thereof from this cause have been reported.

Diagnosis.—Repeated vomiting occurs in over 80 per cent of cases. The vomitus is characteristically brownish-red and extremely copious. It contains no bile. Pain is situated in the left upper quadrant of the abdomen and in 30 per cent of cases in the left

lower thorax as well. Usually the pain is severe, and to commence with is colicky in character but is eased by gastric aspiration later it becomes unrelenting Hiccup is rather frequent. Only in 11 per cent of cases is pain referred to the left shoulder Dyspnœa sometimes severe is not infrequent and directs attention to the thorax. As a rule there is left-sided thoracic hyper resonance rarely there is dullness due to fluid. Paracentesis thoracis is dangerous because of the probable presence in the thorax of dilated stomach or obstructed intestinal coils. In obstructed diaphragmatic hernia borborygmi are often heard on auscultation of the thorax. The heart is sometimes displaced to the right. If a patient experiences sudden pain in the upper abdomen and lower thorax, obstructed diaphragmatic hernia should always be considered as a possibility

Radiography nearly always reveals conclusive evidence of obstructed diaphragmatic hernia. A large air-bubble is seen above the normal anticipated level of the diaphragm. The presence of free air above the diaphragm suggests gangrene and perforation of a herniated hollow viscus.

Treatment.—Urgent operation is required. Some recommend a phrenic crush, in the hope that by paralysing the corresponding side of the diaphragm the obstruction will be relieved. Such a course is usually unsafe, and as a curative measure is useless.

Pre-operative Treatment —Intravenous dextrose-saline solution, gastric aspiration, and sometimes oxygen therapy are required. Plasma or blood is given during the operation, which should be undertaken as soon as possible in most cases.

Operation —It is most advisable to be prepared to undertake an abdominothoracic incision should it prove necessary To this end, to permit extension of the incision into the thorax (*see* p. 399), arrangements should be made beforehand. Actually in a high proportion of reported cases the whole operation has been carried out through the abdomen.[1] It is often necessary to nick the constricting ring before the entrapped contents can be liberated When a portion of the stomach (usually an area on the greater curvature) is gangrenous, obviously non viable tissue is excised. The edges are then trimmed until healthy freely bleeding stomach wall is observed on all sides of the defect which is then repaired with a double layer of sutures. If possible, avoid performing orthodox subtotal gastrectomy in this condition, for the mortality approaches 100 per cent.

Katharine Branson's case —

A woman of 68 who complained of dyspepsia was shown, by barium meal, to have a large hiatus hernia. In view of her frail state, crushing the left phrenic nerve was carried out Two months later she was admitted as an emergency wasted and dehydrated with acetone in her breath. For one week she had had repeated vomiting and epigastric pain, especially after drinking Intravenous dextrose-saline solution improved her general condition, but even sips of water greatly increased the pain and vomiting With a plasma infusion running, the abdomen was opened by a left paramedian incision. Much of the stomach was in the thorax. It proved relatively easy to free adhesions around the neck of the sac and draw the stomach into the abdomen. The edges of the abnormal orifice in the left side of the diaphragm were approximated with interrupted sutures. Recovery

S Pearson's case —

A female aged 72, seven years previously sustained fractured ribs in a motor accident. The attack commenced during the previous night with sudden severe epigastric pain, vomiting and dyspnœa.

On admission the patient was placed in an oxygen tent. That a right diaphragmatic hernia was present was clearly shown by an X ray film. The abdomen was opened through a right rectus incision. Intestine could be felt but not seen, passing through an opening in the diaphragm behind the right lobe of the liver The abdominal incision was carried upwards and outwards through the right 8th intercostal space, and the pleural cavity was entered. Within the pleura there was much blood-stained fluid and a loop of mahogany-coloured ileum. The hiatus was enlarged, the ileum was returned to the abdomen, the diaphragm repaired, and a catheter was introduced through the 9th interspace The thorax was then closed. Attention was then directed to the strangulated intestine 5 ft (1 5 m.) of which was resected, followed by side-to-side anastomosis. Blood transfusion was given. The patient made a slow recovery

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[1] R. E. Gross states that the abdominal approach is far superior in babies. It is much easier to pull the abdominal viscera out of the chest from below than to push them down from above

STRANGULATION OF SMALL INTESTINE FOLLOWING LEFT ILIAC COLOSTOMY OR ILEOSTOMY

Unless it is obliterated by the method described on p. 448 the operation of left iliac (and left rectus) colostomy produces a peritoneal tunnel lateral to the artificial anus. This isthmus, virtually a retroperitoneal fossa, is a proven cause of small-gut intestinal obstruction. When intestinal obstruction (may be renewed intestinal obstruction) occurs in a patient who has a left-sided colostomy it is most advisable to be cognizant of the possibility of this artificial peritoneal tunnel being the cause of the obstruction. In the absence of other evidence, this diagnosis should be presumed and the abdomen should be explored in the first instance through an incision below and to the lateral side of the colostomy opening. The strangulation usually occurs from below upwards, as shown in *Fig.* 581.

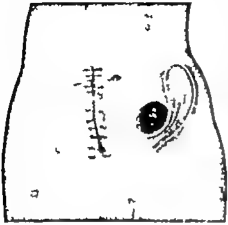

Fig. 581.—Strangulation of a loop of small intestine in the peritoneal tunnel caused by a left iliac colostomy.

An identical type of obstruction sometimes occurs in cases of ileostomy, a coil of small intestine becoming imprisoned within a para-ileostomy gutter that has not been obliterated efficiently.

Intestinal Obstruction following Partial Gastrectomy and Gastrojejunostomy.—*See* p. 299.

ACUTE OBSTRUCTION BY NEOPLASMS OF THE SMALL INTESTINE

A malignant neoplasm of the small intestine is the cause in 6 per cent (Bollinger and Fowler) of all cases of acute intestinal obstruction. It is therefore a more frequent cause than, say, a Meckel's diverticulum or a retroperitoneal hernia. Of 6 personal cases, 5 were carcinomata, 1 a lymphosarcoma. In one instance ileotransverse colostomy was performed and three weeks later the growth was excised. In the other cases resection was carried out at the initial operation and the continuity of the gut was restored by end-to-end anastomosis. The ultimate prognosis in cases of malignant neoplasm of the small intestine is less favourable than that of carcinoma coli.

OBSTRUCTION BY GALL-STONE

Impaction of a gall-stone within the small intestine occurs five times more frequently in women; it is a form of intestinal obstruction peculiar to the elderly, and is responsible for about 2 per cent of all cases of intestinal obstruction.

Typically the obstruction relents and exacerbates. The gall-stone becomes impacted, it is driven onwards by turbulent peristalsis, only to become impacted once more farther down the intestine. Finally peristalsis fails to move it onwards. While it is true that impaction usually occurs in the lower ileum, impaction in the upper ileum or the jejunum is not uncommon. Although abdominal distension is often obvious, minor degrees of it are sometimes obscured by the obesity of the patient and accurate evaluation can only be obtained by a plain radiograph of the abdomen. Usually abdominal tenderness (due to pressure necrosis) is present.

Radiography should indicate whether or not distended loops of small intestine are present, and occasionally the stone contains enough calcium salts to be radio-opaque

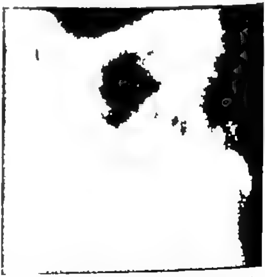

Fig. 582.—Plain radiograph showing distended loop of jejunum and a gall-stone on the left side of the abdomen. (*R. Milnes Walker.*)

(*Fig* 582). Two useful additional radiological signs in gall-stone ileus are (1) the presence of air in the biliary tree and (2) the tendency for the colon to be unduly empty of gas.

In relevant cases the hope that a gall-stone is the underlying cause buoys up the surgeon in insisting that no case of intestinal obstruction should be abandoned as hopeless and that advanced age is not necessarily a contra indication to operation

Mrs. F., aged 81 had complete intestinal obstruction for a week. Vomiting had been persistent and in the bowl beside her was a small quantity of obviously fæcal vomit. She did not want to live, and asked for a larger dose of morphine than she had been receiving The abdomen was greatly distended and peristaltic waves could be seen. It was with considerable difficulty that the relatives were persuaded that an operation was justifiable

On opening the abdomen under local anæsthesia by a para median incision at the level of the umbilicus, the transverse colon was seen to be collapsed. On passing the hand amidst the distended coils towards the pelvis a hard object (the gall stone) was detected. Without allowing the intestines to prolapse the affected segment was brought out of the wound and the gall-stone (*Fig* 583) removed in the manner described below Recovery was uneventful.

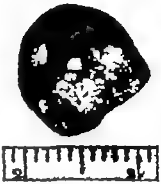

Fig 583. — Gall-stone which caused obstruction removed from the case quoted in the text.

Enterotomy for Gall-stone impacted in the Small Intestine — Often as soon as the hand has entered the peritoneal cavity that portion of intestine containing the stone will be encountered It is worth while remembering that cases of dual obstruction by gall-stones have been reported.

Once the stone is located the portion of bowel containing it is withdrawn gently and after stripping the gut of its contents, a clamp is applied (*Fig* 584). To manœuvre the stone from its resting place either onwards or backwards has advantages—certainly it ensures that the gut is opened where there is no mucosal ulceration. However if such manipulations cannot be effected by the gentlest pressure there should be no hesitation in incising directly over the stone

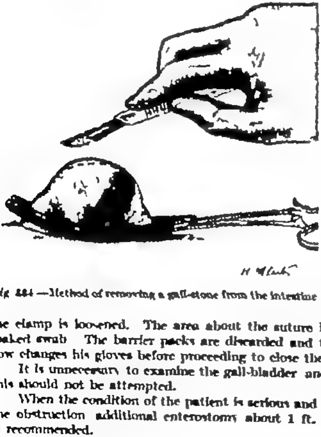

Fig 584 —Method of removing a gall-stone from the intestine

After every precaution has been taken to isolate the immediate vicinity with abdominal packs the intestine is opened by a longitudinal incision on its anti mesenteric border After the stone has been expressed it will be found easier to sew up the intestine in the longitudinal axis, and as there is no danger of undue narrowing this is the procedure of choice Two layers of sutures are necessary Having inspected the suture line the clamp is loosened. The area about the suture line is wiped carefully with a saline-soaked swab The barrier packs are discarded and the clamp is removed. The surgeon now changes his gloves before proceeding to close the abdomen.

It is unnecessary to examine the gall-bladder and in elderly persons in poor condition this should not be attempted.

When the condition of the patient is serious and there is considerable dilatation above the obstruction additional enterostomy about 1 ft. (30 cm.) above the site of impaction is recommended.

Alternative methods—(*a*) digital disintegration and (*b*) squeezing the stone onwards through the ileocæcal valve—are only mentioned to be condemned. In most cases the stone is so dense and is impacted so firmly that to attempt to fragment it between the finger and thumb or to move it onward are so traumatizing to the inflamed intestine as to jeopardize its viability

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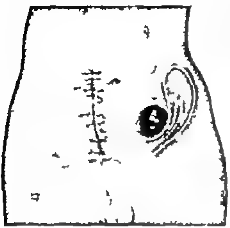

Fig 381 —Strangulation of loop of small intestine in the peritoneal tunnel caused by left iliac colostomy

An identical type of obstruction sometimes occurs in cases of ileostomy a coil of small intestine becoming imprisoned within a para ileostomy gutter that has not been obliterated efficiently

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Fig 382.—Plain radiograph showing distended loop of jejunum and a gall-stone on the left side of the abdomen. (*R. Milnes Walker*)

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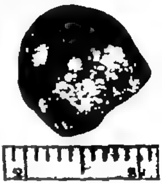

Fig 583. — Gall-stone which caused obstruction removed from the case quoted in the text.

Enterotomy for Gall-stone impacted in the Small Intestine — Often as soon as the hand has entered the peritoneal cavity that portion of intestine containing the stone will be encountered. It is worth while remembering that cases of dual obstruction by gall-stones have been reported.

Once the stone is located the portion of bowel containing it is withdrawn gently and after stripping the gut of its contents, a clamp is applied (*Fig* 584). To manœuvre the stone from its resting place either onwards or backwards has advantages—certainly it ensures that the gut is opened where there is no mucosal ulceration. However if such manipulations cannot be effected by the gentlest pressure there should be no hesitation in incising directly over the stone.

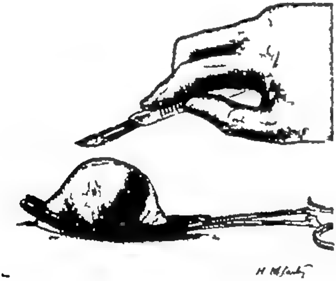

Fig 584 —Method of removing a gall-stone from the intestine.

After every precaution has been taken to isolate the immediate vicinity with abdominal packs the intestine is opened by a longitudinal incision on its anti mesenteric border After the stone has been expressed it will be found easier to sew up the intestine in the longitudinal axis, and as there is no danger of undue narrowing this is the procedure of choice. Two layers of sutures are necessary Having inspected the suture line the clamp is loosened. The area about the suture line is wiped carefully with a saline-soaked swab. The barrier packs are discarded and the clamp is removed. The surgeon now changes his gloves before proceeding to close the abdomen.

It is unnecessary to examine the gall bladder and in elderly persons in poor condition this should not be attempted.

When the condition of the patient is serious and there is considerable dilatation above the obstruction additional enterostomy about 1 ft. (30 cm.) above the site of impaction is recommended.

Alternative methods—(*a*) digital disintegration, and (*b*) squeezing the stone onwards through the ileocæcal valve—are only mentioned to be condemned. In most cases the stone is so dense and is impacted so firmly that to attempt to fragment it between the finger and thumb or to move it onwards are so traumatizing to the inflamed intestine as to jeopardize its viability

STRANGULATION OF SMALL INTESTINE FOLLOWING LEFT ILIAC COLOSTOMY OR ILEOSTOMY

Unless it is obliterated by the method described on p. 448 the operation of left iliac (and left rectus) colostomy produces a peritoneal tunnel lateral to the artificial anus. The isthmus, virtually a retroperitoneal fossa, is a proven cause of small-gut intestinal obstruction. When intestinal obstruction (may be renewed intestinal obstruction) occurs in a patient who has a left-sided colostomy it is most advisable to be cognizant of the possibility of this artificial peritoneal tunnel being the cause of the obstruction. In the absence of other evidence, this diagnosis should be presumed and the abdomen should be explored in the first instance through an incision below and to the lateral side of the colostomy opening. The strangulation usually occurs from below upwards, as shown in *Fig.* 581.

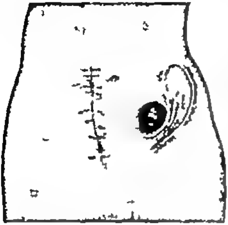

Fig. 581.—Strangulation of a loop of small intestine in the peritoneal tunnel caused by a left iliac colostomy.

An identical type of obstruction sometimes occurs in cases of ileostomy, a coil of small intestine becoming imprisoned within a para-ileostomy gutter that has not been obliterated efficiently.

Intestinal Obstruction following Partial Gastrectomy and Gastrojejunostomy.—*See* p. 299.

ACUTE OBSTRUCTION BY NEOPLASMS OF THE SMALL INTESTINE

A malignant neoplasm of the small intestine is the cause in 6 per cent (Bollinger and Fowler) of all cases of acute intestinal obstruction. It is therefore a more frequent cause than, say, a Meckel's diverticulum or a retroperitoneal hernia. Of 6 personal cases, 5 were carcinomata, 1 a lymphosarcoma. In one instance ileotransverse colostomy was performed and three weeks later the growth was excised. In the other cases resection was carried out at the initial operation and the continuity of the gut was restored by end-to-end anastomosis. The ultimate prognosis in cases of malignant neoplasm of the small intestine is less favourable than that of carcinoma coli.

OBSTRUCTION BY GALL-STONE

Impaction of a gall-stone within the small intestine occurs five times more frequently in women. It is a form of intestinal obstruction peculiar to the elderly, and is responsible for about 2 per cent of all cases of intestinal obstruction.

Typically the obstruction relents and exacerbates. The gall-stone becomes impacted, it is driven onwards by turbulent peristalsis, only to become impacted once more farther down the intestine. Finally peristalsis fails to move it onwards. While it is true that impaction usually occurs in the lower ileum, impaction in the upper ileum or the jejunum is not uncommon. Although abdominal distension is often obvious, minor degrees of it are sometimes obscured by the obesity of the patient, and accurate evaluation can only be obtained by a plain radiograph of the abdomen. Usually abdominal tenderness (due to pressure necrosis) is present.

Fig. 582.—Plain radiograph showing distended loop of jejunum and a gall-stone on the left side of the abdomen. (*R. Milnes Walker.*)

Radiography should indicate whether or not distended loops of small intestine are present, and occasionally the stone contains enough calcium salts to be radio-opaque

(*Fig* 383). Two useful additional radiological signs in gall-stone ileus are (1) the presence of air in the biliary tree and (2) the tendency for the colon to be unduly empty of gas.

In relevant cases the hope that a gall-stone is the underlying cause buoys up the surgeon in insisting that no case of intestinal obstruction should be abandoned as hopeless, and that advanced age is not necessarily a contra indication to operation.

Mrs. E., aged 81, had complete intestinal obstruction for a week. Vomiting had been persistent and in the bowl beside her was a small quantity of obviously fæcal vomit. She did not want to live and asked for a larger dose of morphine than she had been receiving. The abdomen was greatly distended and peristaltic waves could be seen. It was with considerable difficulty that the relatives were persuaded that an operation was justifiable.

On opening the abdomen under local anæsthesia by a para median incision at the level of the umbilicus, the transverse colon was seen to be collapsed. On passing the hand amidst the distended coils towards the pelvis a hard object (the gall-stone) was detected. Without allowing the intestines to prolapse the affected segment was brought out of the wound and the gall-stone (*Fig* 383) removed in the manner described below. Recovery was uneventful.

Fig. 383.—Gall-stone which caused obstruction removed from the case quoted in the text.

Enterotomy for Gall-stone impacted in the Small Intestine.—Often as soon as the hand has entered the peritoneal cavity that portion of intestine containing the stone will be encountered. It is worth while remembering that cases of dual obstruction by gall-stones have been reported.

Once the stone is located the portion of bowel containing it is withdrawn gently and after stripping the gut of its contents, a clamp is applied (*Fig* 384). To manœuvre the stone from its resting place either onwards or backwards has advantages—certainly it ensures that the gut is opened where there is no mucosal ulceration. However, if such manipulations cannot be effected by the gentlest pressure, there should be no hesitation in incising directly over the stone.

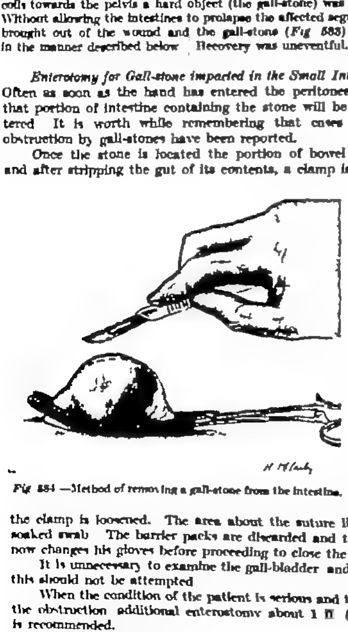

Fig 384.—Method of removing a gall-stone from the intestine.

After every precaution has been taken to isolate the immediate vicinity with abdominal packs the intestine is opened by a longitudinal incision on its antimesenteric border. After the stone has been expressed it will be found easier to sew up the intestine in the longitudinal axis, and as there is no danger of undue narrowing this is the procedure of choice. Two layers of sutures are necessary. Having inspected the suture line the clamp is loosened. The area about the suture line is wiped carefully with a saline-soaked swab. The barrier packs are discarded and the clamp is removed. The surgeon now changes his gloves before proceeding to close the abdomen.

It is unnecessary to examine the gall-bladder, and in elderly persons in poor condition this should not be attempted.

When the condition of the patient is serious and there is considerable dilatation above the obstruction, additional enterostomy about 1 ft. (30 cm.) above the site of impaction is recommended.

Alternative methods—(*a*) digital disintegration, and (*b*) squeezing the stone onwards through the ileocæcal valve—are only mentioned to be condemned. In most cases the stone is so dense and is impacted so firmly that to attempt to fragment it between the finger and thumb or to move it onwards are so traumatising to the inflamed intestine as to jeopardise its viability.

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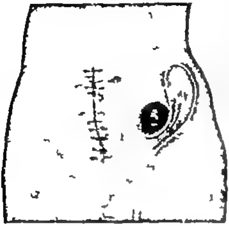

Fig 581 —Strangulation of a loop of small intestine in the peritoneal tunnel caused by left iliac colostomy

An identical type of obstruction sometimes occurs in cases of ileostomy a coil of small intestine becoming imprisoned within a para-ileostomy gutter that has not been obliterated efficiently

Intestinal Obstruction following Partial Gastrectomy and Gastrojejunostomy —*See* p. 299

ACUTE OBSTRUCTION BY NEOPLASMS OF THE SMALL INTESTINE

A malignant neoplasm of the small intestine is the cause in 8 per cent (Bollinger and Fowler) of all cases of acute intestinal obstruction It is therefore a more frequent cause than say a Meckel s diverticulum or a retroperitoneal hernia. Of 6 personal cases, 5 were carcinomata, 1 a lymphosarcoma. In one instance ileotransverse colostomy was performed and three weeks later the growth was excised. In the other cases resection was carried out at the initial operation and the continuity of the gut was restored by end-to-end anastomosis. The ultimate prognosis in cases of malignant neoplasm of the small intestine is less favourable than that of carcinoma coli.

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Impaction of a gall-stone within the small intestine occurs five times more frequently in women It is a form of intestinal obstruction peculiar to the elderly and is responsible for about 2 per cent of all cases of intestinal obstruction.

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Fig. 582. — Plain radiograph showing distended loop of jejunum and a gall-stone on the left side of the abdomen. (*R. Milnes Walker*)

Radiography should indicate whether or not distended loops of small intestine are present, and occasionally the stone contains enough calcium salts to be radio-opaque

(*Fig* 582). Two useful additional radiological signs in gall-stone ileus are (1) the presence of air in the biliary tree and (2) the tendency for the colon to be unduly empty of gas.

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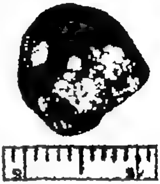

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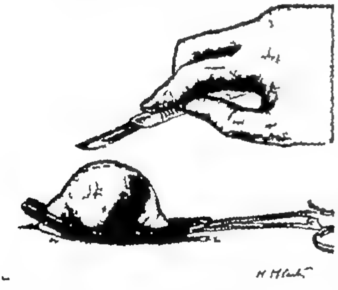

Fig. 584.—Method of removing a gall-stone from the intestine.

After every precaution has been taken to isolate the immediate vicinity with abdominal packs the intestine is opened by a longitudinal incision on its antimesenteric border. After the stone has been expressed it will be found easier to sew up the intestine in the longitudinal axis, and as there is no danger of undue narrowing this is the procedure of choice. Two layers of sutures are necessary.

Having inspected the suture line the clamp is loosened. The area about the suture line is wiped carefully with a saline-soaked swab. The barrier packs are discarded and the clamp is removed. The surgeon now changes his gloves before proceeding to close the abdomen.

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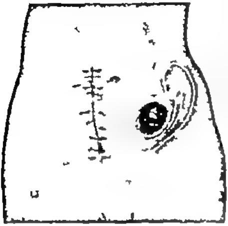

Fig. 581.—Strangulation of a loop of small intestine in the peritoneal tunnel caused by a left iliac colostomy.

An identical type of obstruction sometimes occurs in cases of ileostomy, a coil of small intestine becoming imprisoned within a para-ileostomy gutter that has not been obliterated efficiently.

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Radiography should indicate whether or not distended loops of small intestine are present, and occasionally the stone contains enough calcium salts to be radio-opaque

Fig. 582.—Plain radiograph showing distended loop of jejunum and a gall-stone on the left side of the abdomen. (R. Milnes Walker.)

Vomiting is often severe.

Hæmatemesis and/or melæna occurs in 28 per cent of cases.

Shock is always present in the early stages.

Abdominal rigidity and tenderness are localized over the infarcted area; later they become generalized due to peritonitis. *Rebound tenderness* is nearly always present.

An indefinite lump is occasionally discernible

Leucocytosis is present only when infection has supervened.

Ascites was present in 18 of 22 cases reported by A. J Cokkinis. While one must remember that the heavy congested coils respond to the laws of gravity and give shifting dullness, the fluid outpouring is often so great as to be unaccounted for by the phenomenon just described. Aspiration through a fine needle shows blood-stained fluid.

Radiology is of little assistance until too late It sometimes shows gas in the small intestine.

Summarizing: The signs are those of intestinal strangulation: If the patient is known to have cardiovascular disease, the tentative diagnosis of mesenteric occlusion should follow suit. However most cases occur idiopathically in otherwise healthy individuals.

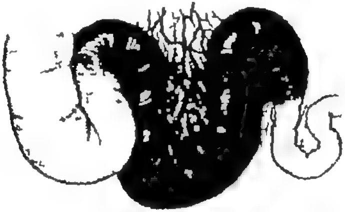

Fig 585.—Mesenteric vascular occlusion

Consequently early diagnosis is very difficult, and doubtless many die incorrectly diagnosed, the syncope and pain being attributed to coronary occlusion. It should ever be before the emergency surgeon that the clinical features of mesenteric vascular occlusion imulate closely those of acute pancreatitis.

Treatment.—Urgent laparotomy is called for [1] Should the patient be greatly shocked lasma or dextran infusion, followed by blood transfusion and oxygen therapy is given luring the shortest pre-operative delay compatible with safety

When the abdomen has been opened blood-stained fluid escapes. According to the te of the occlusion, and especially the length of time that has elapsed since the occlusion, he affected intestine is dark red (very early—seldom seen) blue purple (*Fig* 585) ahogany-coloured or black, fading to normality above and at a variable distance ding to normality below When resection is carried out within twelve hours, there is ery fair prospect of recovery As time goes on the chances of survival become correspondly slender If the patient's condition allows, and it usually does, resection must be formed—wide resection—into really healthy gut above and below Many feet of stine may have to be removed but as pointed out before it is just as easy to remove as 6 in. In W R Morris's patient intra-arterial transfusion so improved the patient's al condition that resection, which otherwise could not have been anticipated, was rmed successfully

echnique of resecting infarcted intestine differs from the standard method in only one t—namely *the infarcted mesentery must also be excised* (*Fig* 586). A V-shaped on which includes the damaged mesentery is the best method of procedure Unless

[1] obert S. Shaw Chief of the Vascular Clinic at Massachusetts General Hospital, performed successful embolectomy for mesenteric vascular occlusion in 1956.

The mortality of gall-stone ileus is high (over 50 per cent) due to (1) late diagnosis; (2) advanced age and other infirmities, notably heart failure and diabetes (3) soiling of the peritoneum at the time of removing the stone; (4) according to Sanders et al., attempting to remedy the cholecyst-duodenal fistula at the time of relieving the obstruction.

See also GALL-STONE OBSTRUCTION OF THE LARGE INTESTINE, p. 460.

OBSTRUCTION BY AN ENTEROLITH

Mrs. N. C., aged 38, thirty hours before admission, whilst washing clothes, had sudden abdominal pain. The pain became less for a few hours, and then returned as a violent, intermittent colic, coming in spasms every ten minutes. On examination, well-marked visible peristalsis was evident. Laparotomy was performed. The gut was very distended down to a point where a stone-like body could be felt in the jejunum. Beyond this point the intestine was collapsed. The affected loop having been isolated by towels, a clamp was applied above and below and a stone measuring 1 in. (2 5 cm.) by 1 in. (2 5 cm.) by ½ in. (1·27 cm.) was removed through a longitudinal incision. The stone was seen to be partially accommodated in a shallow diverticulum in the mesenteric border. Because the intestine was narrow at this point, it was sewn up transversely in two layers. The gall-bladder was examined and found to be normal, and the abdomen was closed. The stone was sent to the laboratory for examination and was pronounced to be an enterolith. Recovery

In H. J Richards's case an enterolith was impacted 2 ft. (60 cm.) above the ileocæcal valve. Therefore there was probably a congenital stricture at this point. The patient, a spinster aged 44 had suffered from recurring attacks of abdominal pain since the age of 5 years. Several feet of small intestine above the point of impaction were dilated to the size of a normal stomach, and of considerably greater thickness. Three enteroliths were removed through a single incision. Recovery

OBSTRUCTION DUE TO FOOD IMPACTION

A great variety of fruit and vegetables have caused intestinal obstruction—orange pith, grape-fruit, mango fibres, a pickled onion. Dried fruit has accounted for many of the reported cases. Nearly always the bolus becomes impacted in the lower ileum, because the improperly masticated dried fruit swells as it passes along the alimentary canal.

The treatment is exactly similar to that of obturation of the small intestine by a gall-stone. A good example of this type of obstruction is as follows —

J A Ross's case —

A man of 76 was admitted with a history of acute intestinal obstruction of 48 hours duration. A well-marked "ladder pattern" was present, and also a small right femoral hernia. A diagnosis of strangulated Richter's femoral hernia was made.

At operation the femoral hernial sac was found empty except for fluid welling into it from the general peritoneal cavity. The sac was removed, the femoral incision closed. The abdomen was then opened by a right lower paramedian incision. Coils of greatly distended small intestine presented in the lower ileum was felt something the size and shape of a small hen's egg distal to which the intestine was collapsed. The solid body having been milked up from the site of impaction, the loop containing it was isolated by packs. Through a longitudinal incision made over it, the incision in the ileum was repaired by two layers of sutures. The abdomen was closed. Recovery

Pathological report The foreign body consists of about two dozen tomato skins.

Intestinal Obstruction due to Worms.—*See* p. 1097

MESENTERIC VASCULAR OCCLUSION

The distribution is as follows —

Arterial	51 per cent
Venous	43 per cent
Arterial plus venous	6 per cent

When sudden arterial occlusion occurs one imagines that anæmic infarction would result but such is not the case because blood enters the capillaries from the free collateral circulation. This continues until thrombosis, starting at the site of embolism, spreads into the arterial arcades of the mesentery

Diagnosis.—

Pain is at first colicky After about an hour it becomes unrelenting Like acute pancreatitis, the pain is often much too severe to be accounted for by the physical signs in the abdomen. A serum-amylase test is often helpful in differentiating between these two conditions.

Vomiting is often severe

Hæmatemesis and/or melæna occurs in 28 per cent of cases.

Shock is always present in the early stages.

Abdominal rigidity and tenderness are localized over the infarcted area; later they become generalized due to peritonitis. Rebound tenderness is nearly always present.

An indefinite lump is occasionally discernible

Leucocytosis is present only when infection has supervened.

Ascites was present in 18 of 22 cases reported by A. J Cokkinis. While one must remember that the heavy congested coils respond to the laws of gravity and give shifting dullness, the fluid outpouring is often so great as to be unaccounted for by the phenomenon just described. Aspiration through a fine needle shows blood-stained fluid.

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Summarizing: The signs are those of intestinal strangulation If the patient is known to have cardiovascular disease, the tentative diagnosis of mesenteric occlusion should follow suit. However most cases occur idiopathically in otherwise healthy individuals.

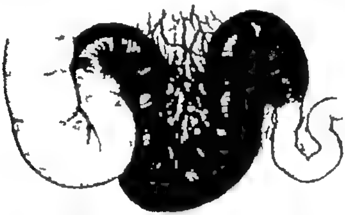

Fig 385.—Mesenteric vascular occlusion.

Consequently early diagnosis is very difficult, and doubtless many die incorrectly diagnosed, the syncope and pain being attributed to coronary occlusion. It should ever be before the emergency surgeon that the clinical features of mesenteric vascular occlusion simulate closely those of acute pancreatitis.

Treatment.—Urgent laparotomy is called for[1] Should the patient be greatly shocked plasma or dextran infusion, followed by blood transfusion and oxygen therapy is given during the shortest pre-operative delay compatible with safety

When the abdomen has been opened blood-stained fluid escapes According to the site of the occlusion, and especially the length of time that has elapsed since the occlusion the affected intestine is dark red (very early—seldom seen), blue, purple (*Fig* 385) mahogany-coloured, or black, fading to normality above and, at a variable distance fading to normality below When resection is carried out within twelve hours, there is a very fair prospect of recovery As time goes on the chances of survival become correspondingly slender If the patient's condition allows, and it usually does, resection must be performed—wide resection—into really healthy gut above and below Many feet of intestine may have to be removed but, as pointed out before it is just as easy to remove 8 ft as 6 in. In W R Morris's patient intra-arterial transfusion so improved the patient's general condition that resection, which otherwise could not have been anticipated was performed successfully

Technique of resecting infarcted intestine differs from the standard method in only one respect—namely *the infarcted mesentery must also be excised* (*Fig* 380). A V-shaped resection which includes the damaged mesentery is the best method of procedure Unless

[1] Robert S. Shaw Chief of the Vascular Clinic at Massachusetts General Hospital, performed the first successful embolectomy for mesenteric vascular occlusion in 1950.

the excision of the mesentery is wide, ligatures will cut through in the sodden semi-gangrenous tissues. To leave even a tiny portion of dead or dying mesentery spells almost certain demise from peritonitis.

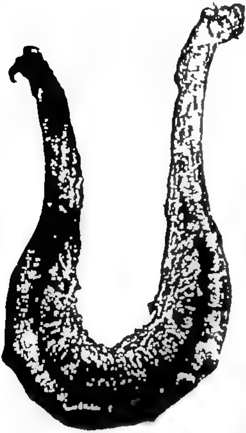

Fig 586.—A segment of intestine excised for thrombosis of a branch of the superior mesenteric artery

An end to-end anastomosis[1] is the most satisfactory and the quickest method of restoring continuity of the intestine.

In several reported cases as much as 20 ft. (6 m.) of the small intestine have been resected successfully for this condition. Some of the patients have been but little troubled with diarrhoea. Nevertheless, if the intestine is blue or purple, i.e., not obviously gangrenous, the question to ask oneself is " Are these enormous resections really necessary ? "

When the Patient's General Condition is too poor to withstand Extensive Resection.—

H. M. M. Williams opened the abdomen of a female patient aged 74, and found two-thirds of the small intestine extremely congested. He closed the abdomen, starved the patient, and administered parenteral fluid, keeping the stomach empty with an aspirating tube. Gradual recovery took place. Thirteen months later the patient was re-admitted with similar symptoms, and she succumbed.

J. C. Lake performed laparotomy upon a man of 42 for intestinal obstruction, and found the small intestine œdematous, purple, and distended to a diameter of 3 in. (7·5 cm.). He closed the abdomen. With intravenous fluid and anticoagulant therapy the patient recovered.

T. G. Orr Jun., opened the abdomen of a male aged 78, and found all of the small intestine purplish-black. He closed the abdomen, performed a bilateral splanchnic block, and administered massive doses of antibiotics. On the third post-operative day he re-opened the abdomen, to find only 1 ft. (30 cm.) of the ileum gangrenous. Resection and end to-side ileocolostomy was performed; the patient recovered.

Splanchnic nerve-block is given to eliminate vasospasm. It permits a second look which may reveal that resection is unnecessary

Technique of Splanchnic Block.—With the patient prone, and a pillow beneath the epigastrium the spinous process of the first lumbar vertebra is identified 7 cm. lateral to this spot a long, fine lumbar puncture needle is inserted near the 12th rib until the body

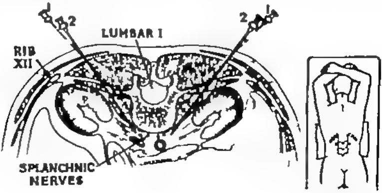

Fig 587 —Bilateral splanchnic block. (*After Gage and Gillespie*)

[1] Unfortunately because the affected mesentery must be excised, extra-abdominal resection (*see* p. 404) *is unsuited to this condition. For the same reason,* exteriorization is futile.

of the first lumbar vertebra is contacted The needle is manœuvred off the body of the first lumbar vertebra and introduced for a further 2–3 cm its tip entering the lumbar cellular tissue (*Fig* 587) where the splanchnic nerves are located The syringe is then connected to the needle and (in order to determine whether a blood vessel has been penetrated) aspiration is attempted. If it has, the needle is withdrawn and reintroduced. Injection of 10–15 ml. of 1 per cent solution of procaine hydrochloride into the retroperitoneal tissue on each side bathes the splanchnics in the solution and anæsthetizes them Extreme care must be taken to avoid injecting procaine into the blood-stream

After-treatment.—In all cases of mesenteric vascular occlusion blood transfusion should be given as soon as possible, and continued as necessary The administration of oxygen is often beneficial. Gastro-intestinal aspiration is essential. Antibiotic treatment should be commenced before operation, and continued for ten days. Tromexan or dindevan can be administered 48 hours after the operation, so as to keep the prothrombin time about 35 sec If bleeding occurs from the wound the effects of the dicoumarol must be neutralized (see p. 928).

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CHAPTER XXXIX

OBSTRUCTION OF THE LARGE INTESTINE

Carcinoma of the colon is second only to post-operative adhesions as the commonest cause of intestinal obstruction. By referring to *Fig* 588 it will be appreciated that the left side of the colon is many times more often the seat of carcinomatous obstruction than the right side or the transverse colon.

Closed-loop Obstruction is seen in its pure form in the carcinomatous stricture of the colon. Distally the colon is occluded by the neoplasm, and in one-third of cases the ileocæcal valve is competent and prevents regurgitation of the contents of the large intestine into the small intestine. Therefore that part of the colon proximal to the neoplasm is closed at both ends (*Fig* 589), and as the result of antiperistalsis, the pressure within the cæcum becomes so high as to compress blood vessels within its walls. Stercoral ulceration gangrene and perforation of the cæcum sometimes occur from this cause. In two-thirds of the cases the ileocæcal valve permits regurgitation and consequently the obstruction is of the simple variety

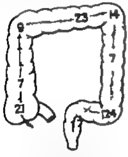

Fig 588.—Site of carcinomatous obstruction in 208 cases of acute—on chronic—intestinal obstruction of the colon, rectum excluded. (*After* D F *Becker*)

Fig 589.—Carcinomatous stricture of the hepatic flexure: Closed-loop obstruction.

Clinically if it can be ascertained that the large intestine, especially the cæcum, is distended more than the central part of the abdomen, it is probable that the obstruction is of the closed loop variety *A plain radiograph showing a great deal of gas in* the cæcum and ascending colon confirms this diagnosis, but if these signs are indefinite, it is unsafe to assume that the ileocæcal valve is incompetent and that a comparatively long time can be spent in gastro-intestinal aspiration. It is permissible to take two or three hours in the preparation of the patient for operation by gastric aspiration and the administration of intravenous dextrose-saline solution, and in two hours most patients can be sufficiently hydrated by a drip infusion running at the standard rate (40 drops per minute)

Fig 590.—Acute on chronic intestinal obstruction. The barium enema displays constriction (carcinoma) of the splenic flexure

Localising the Site of the Obstruction.—When facilities for radiography exist a barium enema should be given, because the information obtained by this simple and quick form of X ray examination is often invaluable (*Fig* 590) With concrete pre-operative information as to the site of the obstruction, it is often possible to plan a procedure that will prove suited to the case instead of improvising one after the abdomen has been opened perhaps in an unsuitable place.

CÆCOSTOMY

Should *blind* cæcostomy be performed when the diagnosis of acute obstruction due to a carcinoma of the colon is practically certain? The answer is "Yes, if the case is one of very great urgency" As a rule it is wiser to explore the abdomen through a right

paramedian incision. When spinal anæsthesia can be employed laparotomy does not add greatly to the length or to the shock of the operation. To perform cæcostomy (or transverse colostomy) without exploring the abdomen is open to serious objections. One can never be absolutely certain of the diagnosis.

Mrs. D. was a thin woman. A hard lump could be palpated in the left iliac fossa, and the ballooned colon, and particularly the cæcum could be seen outlined. The cæcum could even be observed rising and falling with the peristaltic waves. Here, I thought, was the ideal case for blind cæcostomy, which was carried out. Six days later distension returned, and the patient went downhill rapidly although the cæcostomy continued to function. Necropsy revealed an intussusception of a supremely operable carcinoma of the splenic flexure. The intussusception was gangrenous and had perforated.

Cæcostomy is certainly not the operation of choice when a growth proves to be inoperable.

Cæcostomy provides excellent *temporary* drainage of the large intestine; the contents of the cæcum are liquid and escape readily. As a permanent artificial anus it is objectionable: liquid fæces are quite uncontrollable and the skin soon becomes excoriated, even with the greatest care.

Summarizing. Lesions proximal to and at the splenic flexure producing acute intestinal obstruction are best treated by emergency cæcostomy. Transverse colostomy in the presence of a lesion at the splenic flexure makes subsequent resection difficult. Many surgeons consider that cæcostomy for obstructing lesions of the left colon is the best procedure because the area of bowel most susceptible to perforation is decompressed the earliest. On the other hand an increasing number of surgeons, led by O. H. Wangensteen, avoid cæcostomy when possible in favour of right transverse colostomy.

Details of the Operation.—It is assumed that the patient will be brought to the operating theatre with a drip infusion running into a vein and with a gastric or intestinal aspiration tube in place. Both the infusion and the aspiration will continue during the operation.

As indicated already, blind cæcostomy will be chosen when the diagnosis of obstruction due to a carcinoma of the colon is practically certain, and the obstruction is far advanced.

Anæsthesia. With suitable premedication, blind cæcostomy can be performed under local anæsthesia, which is advised. When absolutely necessary the anæsthetic can be supplemented by a small dose of thiopentone given into the rubber tubing of the infusion apparatus.

In other circumstances a spinal anæsthetic is generally advisable. If the patient has had fæcal vomiting an inhalation anæsthetic should be avoided.

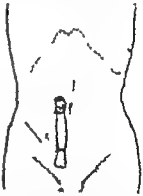

Fig. 591.—Laparotomy has been performed and it has been decided to perform cæcostomy. The laparotomy wound is closed and covered with an anchor dressing. The incision for cæcostomy is shown.

Preliminary Laparotomy will enable the nature and the exact location of the obstruction to be ascertained with precision. If it is deemed advisable to perform cæcostomy a separate gridiron incision is made (*Fig.* 591).

It must be realized that the performance of laparotomy does not help one to determine whether a distended cæcum is one that can be delivered easily or not through an incision in the right iliac fossa.

Technique of Cæcostomy.—The abdomen is opened through a fairly large, rather higher than usual, gridiron incision; however, to avoid possible later obstruction to the cæcum, it is advisable to divide the fibres of the internal oblique in the line of the skin incision instead of splitting them.

When the cæcum is greatly distended, it frequently bulges into the wound. If it does so, do not even touch it at this stage. A cæcum that bulges forth on its own account is hugely distended with gas, half filled with liquid fæces and its wall extremely thin, and often friable. Handling it even gently may cause it to burst. Efforts to fix this tissue-paper-like gut to the peritoneum will result in a whistling of gas escaping from the stitch hole and as likely as not, to our dismay, this will be followed by a further hissing accompanied by a fine fæcal spray. This unhappy predicament can be circumvented in the following way: arrange two moist abdominal packs neatly about the wound, remembering

there is no need to hurry especially when local anaesthesia is employed. Remove the plunger from a 10-ml. or 20-ml. syringe, and affix a large hypodermic (not an aspirating) needle to it. If it is a syringe that is used for local anaesthesia, it is of paramount importance that it should be specially cleansed and autoclaved after the operation is over. Plunge the needle into the cæcum (*Fig.* 592), and let the hissing referred to above take place into the barrel of the syringe, which has been covered by a swab. The cæcum collapses like a pricked balloon, and as it does so its wall gains in substance and becomes manageable. It is astounding what a remarkable change occurs in its texture. Remove the needle and pick up delicately with a hæmostat a tiny segment of the cæcum that contained the prick hole and ligate it.

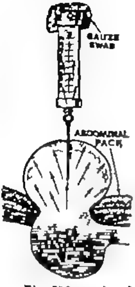

Fig. 592. — A safe method of deflating a cæcum distended to bursting point.

Palpate the cæcum. Very gently endeavour to deliver it. Sometimes the cæcum has a mesentery and the whole organ can be brought out of the wound easily.

If the cæcum, which is often friable and sometimes partially gangrenous, cannot be exteriorized easily a longitudinal incision is made through the peritoneum covering the posterior abdominal wall close to the attached border of the cæcum. In order to do this under full vision without pulling on the cæcum it may be necessary to enlarge the incision a little. With the index finger, the cæcum is freed from its loose retroperitoneal attachments.

When Exteriorization is possible.—In most cases the mobilized cæcum can be withdrawn easily. If so, proceed as follows: an intestinal clamp is not employed. A malleable spigot (*see Fig.* 607) or a length of ½ in. (1.3 cm.) rubber tubing is passed under the upper part of the cæcum through a small hole made in an avascular part of the true (or artificially-made) mesocæcum. If rubber tubing is used, in order to prevent the tube becoming displaced, each end is doubled over and maintained in that position by a strong ligature. The peritoneum is closed above and below the protruding cæcum, but *no attempt is made to pass stitches through the cæcal wall.* It may be desirable to employ one or two skin stitches, but as a rule the wound is packed lightly with tulle gras, which is also laid on the surrounding skin. Dry abdominal packs are superimposed. The cæcum is pierced by three or four No. 17 gauge hollow needles (*Fig.* 593): gas, and a little fæcal matter escape through the needles. A light gauze dressing is applied and maintained by a many tailed bandage.


Fig. 593.—Cæcostomy. Stage 1 completed. Gas and a little fluid fæces escape through the hollow needles. (*After Wolfson and Greenberg*[1])

After six hours the cæcum is inspected. If necessary the needles are readjusted. If one or more is blocked, its lumen is freed by water injected from a syringe.

During the interval between exteriorizing and opening the cæcum electrolytic balance is restored and maintained, and antibiotic therapy is given. The interval gives time for the cæcum to become at least partially adherent to the abdominal wall, which

[1] Using this technique Wolfson and Greenberg quote 2 deaths in a series of 150 cases.

greatly reduces the incidence of infection of the cæcostomy wound and the peritoneum, both of which occur more frequently when other methods of performing cæcostomy are employed. It is these complications that are responsible for the relatively high mortality of cæcostomy as compared with transverse colostomy as a means of relieving acute on chronic intestinal obstruction.

After forty-eight hours A purse-string suture is inserted into the cæcal wall in such a manner that when the time comes for it to be tied, it will turn in about ½ in. (1·25 cm.) of the cæcal wall around the rubber tube yet to be inserted. In the centre of the area surrounded by the purse-string suture a small stab incision is made preferably with a cautery The edges of the incision are grasped in hæmostats, and by this means the cæcum can be lifted up while a tube with its end spigoted is passed into the cæcum for 2–3 in (5–7·5 cm.) and fastened to the cæcal wall by a catgut stitch. The purse-string suture is tied. The spigot is removed and the tube is connected by a glass connexion to a further length of tubing which is led into a bedside bottle, taking precautions that there is no kinking or drag on the cæcostomy tube. This operation can be undertaken with the patient in bed, no anæsthesia being required. If the cæcostomy is not draining copiously the nurse is instructed to uncouple the glass connexion, and being careful not to pull upon the cæcostomy tube to run half a pint (280 ml.) of water into the cæcum every four hours.

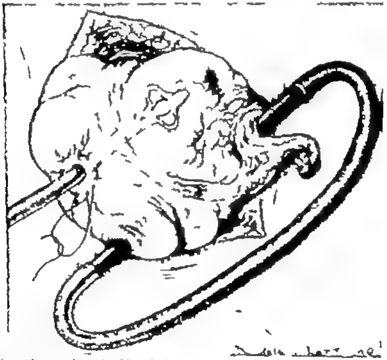

Fig 394.—Inserting a spigoted rubber drainage tube (or catheter) into the exteriorized cæcum.

Difficulties and Dangers of Cæcostomy —

1 On opening the peritoneum it is not a very rare occurrence for the *cæcum to perforate spontaneously* Usually the perforation is small and the hissing of escaping gas is heard. See that the assistant is plentifully supplied with swabs and when possible a mechanical sucker to remove expeditiously any fæcal matter that escapes. Deliver the portion of the cæcum which has perforated, extending the incision upwards if necessary Apply a clamp and sew up the perforation, liberally invaginating the cæcal wall in the immediate neighbourhood. Having closed the perforation, perform cæcostomy if possible by the method of exteriorizing the cæcum : in this instance insert a tube[1] into the cæcum (*Fig* 394) It is not good practice to utilize the perforation for the designed orifice too often this results in the purse-string suture cutting out and a gross contamination of the peritoneum. If it is not possible to exteriorize the cæcum, suture the peritoneum to the cæcal wall as shown in *Fig* 395.

[1] If a de Pezzer catheter is employed, it is better to cut off the tip of the mushroom head so as to leave a wide-open lumen.

2. *The cæcum is surmounted by gangrenous patches.* In one such case the cæcum was brought on to the surface as far as possible and stitched to the cut edges of the lacking

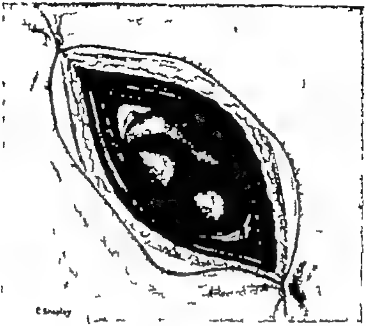

Fig 595.—Cæcum, surmounted by gangrenous patches, anchored by stitches to the peritoneum and muscle.

(*Fig* 595) A large portion of the cæcum sloughed. By the seventh day the appearance was that of a large, but otherwise normal cæcostomy and the result proved satisfactory

Fig 596.—Acute on chronic intestinal obstruction. 1 Laparotomy performed An operable carcinoma of the pelvic colon was found. 2, Cæcostomy incision The cæcum was found to be bound down and could not be delivered, therefore this wound was closed. 3 Transverse colostomy performed (The incisions 1 and 2 have protective dressings tied on)

3. *The cæcum is bound down and cannot be delivered.* I have had the misfortune to encounter two such cases where manipulations designed to deliver the cæcum caused a large perforation. When the cæcum is bound down do not attempt cæcostomy Close the wound and perform transverse colostomy (*Fig* 596.)

4 *Cæcostomy is a difficult operation in the obese* If there is a choice between cæcostomy and transverse colostomy always choose transverse colostomy in a fat person.

Golden rule When full exteriorization is impossible, abandon cæcostomy and perform transverse colostomy

RIGHT TRANSVERSE COLOSTOMY

The transverse colon is well adapted to serve as a colostomy seeing that it is the most mobile, the narrowest, and the least distensible portion of the colon. The advantages of transverse colostomy in acute on chronic obstruction of the pelvic colon and the rectum have been discussed already

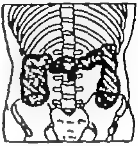

Fig. 597.—A ballooned large intestine shows well on a plain radiograph film. If a sixpenny piece is placed on the umbilicus, the relationship of the transverse colon to the abdominal wall can be visualized. (*After Wangensteen.*)

Radiography.—A plain radiograph is taken a small coin being placed on the umbilicus for purposes of orientation. The ballooned transverse colon will show on the film and its relation to the umbilicus can be visualized (*Fig* 597). In the operating theatre with the radiograph before one a transverse incision can be made *directly over the transverse colon*

Anæsthesia.—The operation can always be undertaken under local infiltration anæsthesia supplemented by nerve-blocking injection of the mesocolon. If for any reason delivery of the colon is difficult the retroperitoneal tissues require infiltration.

Incision.—A transverse incision 3½–4 in. (8.75–10 cm.) long is made over the right rectus muscle, usually midway between the umbilicus and the xiphisternum. The medial extremity of the incision extends to the linea alba. As the incision is deepened, the fibres of the right rectus muscle are severed exposing the posterior rectus sheath, the fibres of which are separated, and the peritoneum is opened in the line of the incision. The greater omentum is gently withdrawn from the wound. By light traction on this structure the transverse colon can be brought to the mouth of the wound, through which it is eased with the fingers. Usually the posterior layer of the greater omentum is attached but lightly to the colon, and it can often be detached by gauze dissection without the necessity of ligating blood vessels In others it must be divided between ligatures. The omentum is returned to the abdomen. A bloodless area is selected in the mesocolon, and through this a spigot is passed. The extruded colon fills the incision almost completely (*Fig* 598). O H Wangensteen advises the use of two spigots placed about 1¼ in. (3.3 cm) from one another (*Fig* 599).

Fig 598.—Right transverse colostomy

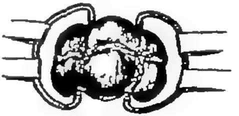

Fig 599.—Two spigot in use T pes, as shown, fastened to the abdominal wall with adhesive plaster keep the rubber tubes away from the bowel. (*After Wangensteen.*)

Closure of the Wound.—One or two cotton stitches will be sufficient to close the medial extremity of the severed rectus sheath. The *edges of the skin* are approximated on either side of the protruding bowel No stitches attach the colon to any of the layers of the abdominal wall. Petroleum-jelly gauze is applied on either side of the wound (see p. 431).

After-care.—Deflation of the distended bowel is accomplished by inserting one or two hollow needles (S.W.G. 18) *into the dome of the bulging intestine* but opening the bowel is delayed for twelve hours. A Paul's tube can then be tied into the bowel (*see* p. 451) without anæsthesia, with the patient in bed. After the Paul's tube becomes loose (five or six days) it is removed, and irrigation of the distal segment can be commenced. This cleanses the colon and reduces inflammatory elements of the tumour mass. At the end of two weeks the mesenteric border of the intestine is cut through with a cautery and the spigot or spigots are removed. This division separates the proximal and distal openings sufficiently to effect almost complete diversion of the fæcal stream.

Fig 600.—A patient who had blind transverse colostomy performed for acute intestinal obstruction. Through the incision a carcinoma of the splenic flexure was palpated. He was too ill for laparotomy to be performed in the usual manner

If a right lower paramedian exploratory incision has been employed right transverse colostomy can be performed through its upper part, although sometimes the incision will need extending upwards for this purpose.

The Disadvantages of Transverse Colostomy.—

1 It is not applicable for the urgent treatment of acute carcinomatous obstruction of the ascending colon.

2 A gangrenous patch in a ballooned cæcum may be overlooked.

3 Repeated irrigations over several days are required to coax the colon to function. This does not appertain in the case of cæcostomy (Rack and Clement.)

LEFT ILIAC COLOSTOMY

Indications (1) In cases of inoperable carcinoma of the rectum (2) In operable cases when perineal excision of the rectum is contemplated.

Technique.—Stand on the left side of the patient. An incision is made like that for appendicectomy by the gridiron method, but on the left side (*Fig* 601). The external oblique is incised and the internal oblique split. The peritoneum is opened. Four hæmostats are placed on the peritoneum in such a way that they are comparable to the four points of the compass. The pelvic colon is now sought it is distinguished from small intestine by its tæniæ and its appendices epiploicæ. The colon is delivered and its upper end is gently drawn taut—a measure which considerably reduces subsequent prolapse of mucous membrane. If after all this has been done, there is too much colon on the surface for our purpose some *of the inferior end of the loop* is tucked back into the abdomen. A spigot is passed through the mesentery under vision (*Fig* 602)

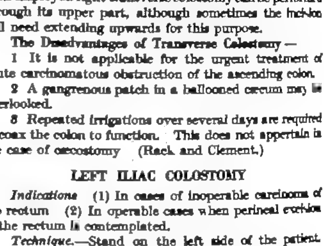

Fig 601.—Incision for left iliac colostomy

Obliterating the Peritoneal Foramen on the Lateral Side of the Colon.—To insert a purse-string suture vertically through the mesentery—vertically so as not to occlude the vascular supply of the intestinal loop—and then through the nearby lateral peritoneum (*Fig* 603) is a wise step. When this purse-string suture has been tied it closes the foramen, which is a proven cause of small-gut intestinal obstruction following colostomy (*see* p. 436).

Continuing the Operation of Left Iliac Colostomy the next step is to stitch the peritoneum to the bowel at four points of the compass. The hæmostats previously applied serve to

Fig 602.—Left iliac colostomy. Passing the spigot through the mesentery.

Fig 603.—Vertical purse-string suture inserted so as to obliterate the peritoneal foramen to the outer side of the colostomy which is a possible source of small-gut intestinal obstruction.

mark these points, and render the peritoneum accessible to the needle. The purse-string suture just described serves to anchor the peritoneum on the east side. The hæmostats marking the north and south are lifted up in turn, and a single stitch approximates the peritoneum to one of the tæniæ coli. When we come to the west side, that is, the medial aspect, it is often advantageous to employ two sutures, one on either side of the spigot. The external oblique is brought together above and below the loop, and the skin is sutured in the same way.

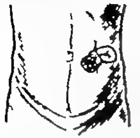

Fig. 601.—Prolapse of the small intestine through a colostomy incision. (*After G. L. Kraus*.)

If time is not an all-important factor, the appendices epiploicæ may be picked up with forceps, ligatured at their base, and removed. Petroleum jelly gauze is arranged to protect the wound (see p. 431). A purse-string is introduced and a large Paul's tube tied into the gut.

Difficulties and Dangers.—

1. It is necessary to *see that the loop withdrawn is not twisted* on its axis. This can be prevented by examining the mesentery.

2. *If the colon cannot be withdrawn* by incising the peritoneum on the outer side of the colon, the mesentery can be mobilized (see *Fig.* 603). This method often acts admirably, but it is dangerous when the gut is greatly distended. If the patient is fat, the mesentery is short, and the gut is ballooned, the best practice is to close the incision and perform transverse colostomy.

3. Do not economize time by *neglecting to sew the peritoneum to the bowel.* I have been called upon to treat two cases where this step had been omitted. In the first a small loop of intestine became herniated through the peritoneum, and on the fifth day caused (renewed) acute intestinal obstruction. In the second case a coil of small intestine prolapsed right out on to the abdominal wall (*Fig.* 604).

4. *If solid fæces are present in the colon above the growth* it is highly improbable that the colostomy will function for a considerable period. If it is imperative for the colon to be drained immediately, transverse colostomy is a better operation.

Blind Left Inguinal Colostomy (colostomy without exploration of the abdomen).—Is occasionally justifiably indicated in the aged.

Method of rendering Fixed Portions of Colon more Mobile.—To be able to render a fixed segment of the colon more mobile is an acquisition. The procedure about to be described can be applied to the left or right half of the colon. By its employment, left iliac colostomy for obstruction, otherwise impracticable, may be rendered possible. One of the applications of the method is as a preliminary measure in the performance of a Paul-Mikulicz operation on the pelvic colon. (*See* p. 433.)

Fig. 603.—Slit of the incision in the peritoneum covering the posterior abdominal wall in order to render more mobile the pelvic colon.

Technique.—The loop of colon is lifted up and drawn medially, while the lateral lip of the abdominal incision is retracted strongly. The peritoneum overlying the posterior abdominal wall to the outer side of the colon is seen clearly. This is incised longitudinally (*Fig.* 603). The retroperitoneal space is then opened up by gauze dissection in the loose areolar tissue beneath the peritoneum. In a number of instances it will be found that, after this measure has been carried out, the colon can be drawn out on to the surface.

Special method for the flexures of the colon. The hepatic and particularly the splenic flexure can frequently be rendered extremely mobile by dividing their suspensory ligaments, thus enabling a Paul-Mikulicz procedure to be carried out.

COLOSTOMY IMMEDIATELY PROXIMAL TO THE NEOPLASM

Although contrary to orthodox practice, some surgeons advocate constructing a temporary colostomy as close as possible to the neoplasm. When the time comes for resection, both the neoplasm and the colostomy can be excised together, thus averting the need for a third operation.

ACCESSORIES TO THE PERFORMANCE OF ANY TYPE OF COLOSTOMY

On Spigots.—A glass rod is often used. A vulcanite spigot (*Fig* 606) with a point is easy to insert, and causes less trauma to the mesentery. A bendable pewter spigot (*Fig* 607) when the ends of a suitable length of rubber tubing have been threaded onto the extremities of the spigot so as to ensure that the spigot does not slip out, can be bent

Fig 606.—Vulcanite spigot. After insertion, the ends of a length of rubber tubing of suitable size are placed over each end of the spigot, which is thus prevented from becoming displaced.

Fig 607.—A bendable spigot made of pewter

to a desired angle and thus neatly fits the varying thicknesses of subcutaneous fat. In the absence of any designed spigot, a glass tube of catgut has been used, but what is far better is a hæmostat. A piece of rubber tubing can be tied to one of the handles, and the other end of the tubing grasped in the jaws of the hæmostat. This ensures that the improvised spigot does not become displaced.

It is far better to leave a spigot in for as long as 2–2½ weeks than to take it out too soon.

Method of inserting a Paul's Tube.—A piece of petroleum jelly gauze about 8 in. × 4 in. (20 cm. × 10 cm.) is taken and it is bisected with scissors for two-thirds of its length. The limbs of the gauze are insinuated under the spigot so that the two arms encircle the colostomy (*Fig* 608 A). With a stitch or two the free arms below the colostomy are re-united (*Fig* 608 B). Thus the junction of the skin and the intestine is covered with the gauze. A piece of jaconet a little larger than the petroleum jelly gauze is taken and it is split and inserted over the petroleum jelly gauze and its limbs are united in precisely the same way. Into the convexity of the gut a purse-string suture is inserted. Within the encircling purse-string the gut is picked up with two hæmostats. Swabs are placed on each side and the assistant holds one in his hand ready to mop up any escaping fæces. A small incision is made into the gut between the two hæmostats, which are held fairly taut in a directly upward direction. This small incision is dilated very gently by opening the jaws of a third pair of forceps. The edge of the opening is now clipped by this third pair of forceps, which is handed to the assistant and a Paul's tube insinuated into the incision

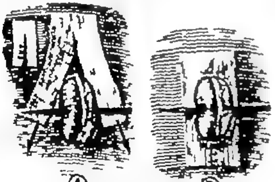

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Fig 608.—A, Method of encircling the colostomy with a gauze protective. B, The protective dressing in place

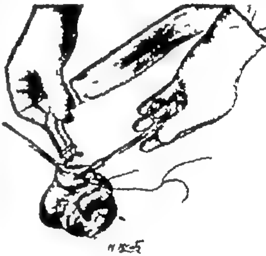

Fig 609.—Method of inserting a Paul's tube

(*Fig* 609) The Paul's tube should pass into the gut right above its second bevel, when the purse-string is tied. Between the first and second bevels a piece of tape is tied tightly (*Fig* 610). Tape is a most useful material for keeping a Paul's tube firmly in position.

A large rubber tube can be tied into colon in the same way as a Paul's tube, with the exception that before tying the purse-string suture the rubber tube is transfixed with a suture that passes through the gut wall. The rubber tube is passed well down the proximal limb of the colostomy, a

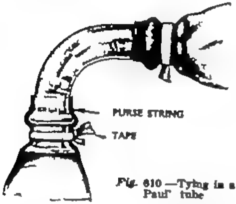

Fig. 610.—Tying in a Paul's tube

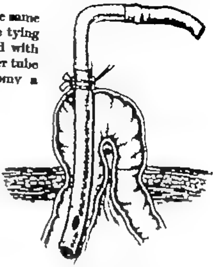

Fig 611.—Method of employing a large rubber tube as a colostomy tube

measure that is advantageous because it obviates compression of the gut by the abdominal musculature. Into the free end of the large rubber tube is inserted a *small* Paul's glass tube which serves as a good connexion (*Fig* 611)

Fig. 612.—Making a "watershed." A, Method in which the strips of adhesive plaster are folded; B, Approximation of the strips held by the surgeon and assistant; C, The strips approximated; D, The "watershed" applied to the abdomen.

Method of protecting a Laparotomy Wound from the Infection of the Colostomy: Making a "Watershed."—A strip of broad adhesive plaster about 6 in. (15 cm.) long is taken and the assistant takes a similar piece of exactly the same length. Facing one another and working independently but simultaneously both the surgeon and the assistant fold their pieces of plaster longitudinally (*Fig* 612 A). The surgeon now approaches the assistant, and the strips of plaster are placed back to back (B and C). The surgeon takes both pieces, the backs of which have adhered to one another, and applies the "watershed" to the abdominal wall between the two wounds (D). *Fig* 613 shows the "watershed" in action. In addition to preventing fæcal contamination of the laparotomy wound, it serves to remind the nurse that the two dressings must be kept separate.

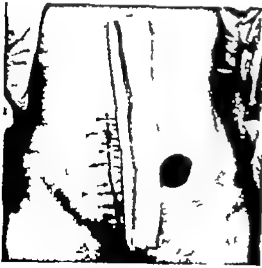

Fig 613.—"Watershed" in action.

Note.—Rubber gloves should be removed before handling the strapping—the plaster adheres so readily to the rubber

PAUL-MIKULICZ OPERATION

The operation should be employed only in cases when the obstruction is subacute and it is judged that sufficient of the bowel to eradicate the cancer bearing area can be exteriorized. All the essential points have been described on p. 306. It is most necessary to emphasize that when this operation is employed in cases of carcinoma of the large gut the affected segment of colon must be rendered mobile enough to bring it freely on to the surface. In these circumstances this is a highly satisfactory method of dealing with cases of carcinoma coli with obstruction.

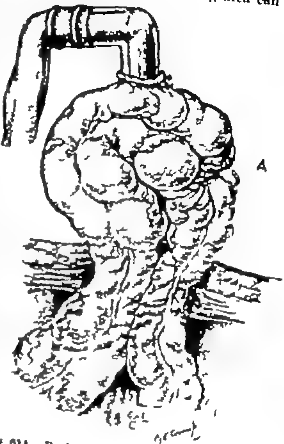

Fig 614.—Paul-Mikulicz operation. The growth is situated at A.

A. F aged 63 was admitted with subacute intestinal obstruction. A barium enema would not pass the hepatic flexure. For years he had suffered from chronic bronchitis. Operation was conducted under combined spinal and local anaesthesia. An obstructing carcinoma of the hepatic flexure was found. By dividing some reflections of peritoneum between the colon and the liver between ligatures, that portion of the colon containing the growth was rendered completely mobile and it could be withdrawn on to the abdominal wall. The two limbs were sutured together according to the instructions given on p. 412, and the operation was completed (*Fig* 614) without difficulty. On the third day after operation the patient commenced to hiccup. This was partially controlled by CO inhalations but eventually the hiccup became so persistent that the left phrenic nerve was exposed and injected with procaine. This cured the hiccup but about this time his chronic bronchitis became subacute and he again gave rise to anxiety but responded to sulphonamide therapy. After that portion of exteriorized colon above skin level had been excised with a cautery the enterotome was applied (*Fig* 615). It fell out of the wound on the eighth day and thereafter the patient was treated in the routine manner.

Fig 615.—*Case* A. F on the fourteenth day after operation. Showing the enterotome in position. *Inset* Mikulicz's enterotome.

ILEOCOLOSTOMY

The danger of ileocolostomy lies in its performance in the presence of a closed-loop obstruction, or in the development of closed loop obstruction after its performance (*Fig.* 616). In operable cases when the obstruction is subacute, this expedient can be employed as an alternative to caecostomy or transverse colostomy but most surgeons prefer external drainage of the bowel. An especial indication for ileocolostomy is acute obstruction due to a neoplasm of the caecum itself but in this instance the caecum must be decompressed in addition. This can be accomplished by inserting a large rubber catheter into the distal divided ileum and passing it through the ileocaecal valve into the caecum. The catheter is anchored to the wall of the ileum, which is closed around the catheter and invaginated by a purse-string suture. Finally the distal ileum (which must be at least 6 in. (15 cm.) long) is brought out through a stab incision in the abdominal wall as a mucous fistula. If this additional step is taken, ileocolostomy can be employed in cases of irremovable obstruction situated anywhere between the caecum and the commencement of the pelvic colon.

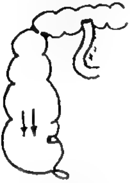

Fig. 616.—Ileo-transverse colostomy closed-loop obstruction imminent.

Ileocolic Anastomosis by the Maylard-Sonnenburg Technique[1]—Comparatively simple in execution, and almost devoid of the danger of leakage at the site of the anastomosis, this method of short-circuiting the proximal end of the bisected lower ileum into the transverse descending iliac or pelvic colon, as circumstances dictate permits, if feasible subsequent partial or subtotal colectomy. An additional advantage of the operation is that the short invaginated segment of small intestine into the large, mimics an ileocaecal valve.

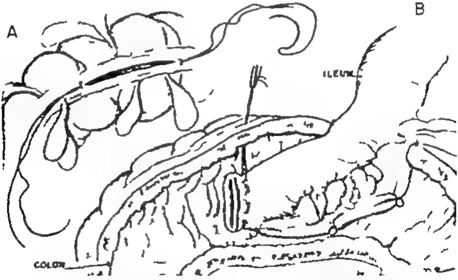

Fig. 617.—Ileocolic anastomosis by the Maylard-Sonnenburg technique.

Step 1. The appropriate loop of ileum is selected—the nearer the ileocaecal valve the better except in the circumstances detailed above. The loop is stripped of its contents so that 1 ft. (30 cm.) of it is collapsed and flaccid. The assistant then applies one short, light rubber-covered clamp to the extreme proximal and one to the extreme distal, end of the empty flaccid loop. Close to the distal side of the proximal rubber-covered clamp two small Payr's crushing clamps are applied by the surgeon diagonally across the small intestine as near to one another as convenient. The intestine is then divided between the clamps, preferably with a cautery. The proximal rubber-covered clamp, no longer required, is removed.

[1] Other indications for this operation are cited on pp. 411–425.

Step 2. Half an inch (1 3 cm.) from the Payr's clamp the proximal divided intestine is surrounded by a *temporary* purse-string suture which, as the Payr's clamp is removed, is drawn fairly taut, but is not tied. In lieu of tying a hæmostat clips together the entering and emerging portions of the suture, thus preventing it becoming loose and allowing fæcal matter to escape.

Step 3. A portion of the colon is selected for the implantation. A tentaculum forceps is used to pick up the central tænia coli and 4 in. (10 cm.) distally is placed another. Should appendices epiploicæ obstruct the full view of the central tænia in this selected 4 in., these tags of fat are picked up in small hæmostats, which are allowed to fall to one or other side. If this fails to give the operator satisfactory visualization of at least 2 in. (5 cm) of the central tænia, the tags of fat are ligated at their bases, and snipped away

Step 4 While steady traction is exerted on the tentacula, the middle 2 in (5 cm.) exactly in the middle line of the tænia is incised to the empty gut's lumen At each extremity of the incision a suture on an eyeless needle is inserted tied, and its free ends await their further important reparative duties (*Fig* 617 A)

Step 5 Attention is now directed to the proximal ileum. The eyeless needle is now severed from the purse-string suture and both ends of the suture are threaded on to a straight round bodied intestinal needle with a large eye, and the hæmostat ensuring the non-loosening of the purse-string suture is removed. The needle is introduced into the

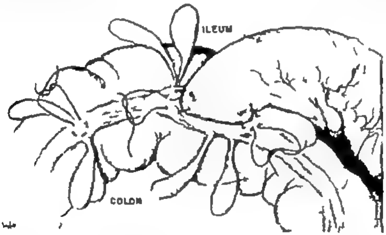

Fig 618.—The Maylard-Sonnenburg anastomosis nearing completion

incision in the colon, its point being brought out through the intestinal wall 2 in distal to the distal extremity of the incision, i.e near the spot where the distal tentaculum still grasps the tænia coli. The needle being contaminated, it is seized in a hæmostat and drawn through the intestinal wall, as also are the ends of the attached purse-string suture. The needle is disengaged and discarded, but the hæmostat is used to clip together the ends of the catgut. Exerting traction on both ends of the suture, the cut end of the proximal ileum is guided through the incision into the colon. Thus the ileum becomes invaginated into the colon for the desired 2 in. The assistant lets go of the distal tentaculum and is handed the hæmostat to exert steady traction on the sutures. The surgeon transfixes the walls of the muscular and serous coats of the ileum at either end with the eyeless needle and suture that were left in readiness for this purpose. These sutures are knotted and cut short (*Fig* 617 B) Each knot is embedded by inserting a Lembert's suture of cotton (*see Fig* 618).

Step 6. Moist abdominal packs are arranged around the site of the anastomosis. The hæmostat held by the assistant is disengaged, and re-engaged *on one end only* of the contaminated catgut, which by means of gentle traction is withdrawn in its entirety Theatre Sister acquiescing the hæmostat and suture are dropped into the "dirty" pail.

Step 7 The puncture through which the length of catgut was withdrawn is closed with a catgut purse-string suture (*Fig* 618) reinforced by a non-absorbable suture applied similarly

Step 8. Further reinforcing sero-muscular sutures are placed along the line of anastomosis.

VOLVULUS OF THE CÆCUM

In Britain, volvulus of the cæcum is more common than volvulus of the sigmoid. Patients who develop this form of volvulus are those possessed of a cæcum and ascending colon with a free mesentery and it is often found that these patients have a common mesentery serving the whole of the intestine from the duodenojejunal flexure to the hepatic flexure of the colon. When this is the case the line of the attachment of the abnormal enterocolic mesentery extends almost horizontally across the abdomen at the level of the second lumbar vertebra.

Fig. 619.—Plain radiograph showing enormously dilated cæcum stretching across the abdomen from the right iliac fossa to the level of the first lumbar vertebra on the left side. R. H. Gardiner's case of volvulus of the cæcum.

Three types of volvulus of the cæcum are recognized :—

1. The axis of rotation is transverse and the cæcum rotates so that its posterior surface looks forward.

2. The axis of rotation is oblique and the lower pole of the cæcum ascends towards the left hypochondrium.

3. Rotation occurs about the long axis of the ascending colon, nearly always in a clockwise direction.

Diagnosis.—Usually there is a history of recurrent attacks of obstruction with distension. Pain is severe and vomiting occurs early. Typically a tense palpable and resonant mass occupies the central or left upper part of the abdomen, and is combined with a concavity of the right iliac fossa, noticeable during the spasm of colic. Visible small intestinal peristalsis is sometimes seen. Radiography shows an oval or hour-glass-shaped gas-filled area occupying the central (*Fig.* 619) or upper part of the abdomen, almost resembling a distended, air-filled stomach, from which it must be distinguished by preliminary gastric aspiration.

Operation.—In order to evaluate the situation properly partial or extensive evisceration is required. If possible the cæcum is untwisted usually in an anti-clockwise direction. Sometimes deflation with a hollow needle (see p. 444) is necessary before untwisting is possible.

If the ascending colon shows no pressure effects, and imprisoned gas escapes along the distal colon, the ileocolic loop is placed in its anatomical position, and the free ileocæcal mesentery is stitched to the parietal peritoneum by a number of unabsorbable sutures.

If a white band of devitalized colon is discernible this must be invaginated, and cæcostomy performed through a special incision.

If the distension is extravagant cæcostomy should always be undertaken.

If there is any doubt as to the viability of the ileocæcal loop it should be exteriorized, using two spigots. The cæcum is then treated as described on p. 447.

There is often sufficient œdema of the ileocæcal valve to cause obstruction of the ileum. A rather stiff catheter (Tiemann's) with lateral holes cut can be passed through the cæcal opening into the ileum to relieve the obstruction of the small intestine.

When exteriorization is necessary the exteriorized loop is excised and the continuity of the intestine restored by ileocolostomy on about the sixth to the eleventh day.

VOLVULUS OF THE SIGMOID

In Britain the condition is rare but in Eastern Europe and particularly in Southern Russia, volvulus of the sigmoid colon (*Fig.* 620) is the commonest cause of intestinal obstruction. Perlmann, reporting this from his clinic in Russia, stated that over 30 per

cent of admissions for obstruction were caused by volvulus. Volvulus of the sigmoid is also common in India, Scandinavia, and among the natives of Peru.

There is usually a history dating back for some time of attacks of abdominal pain with constipation, followed by diarrhœa and copious evacuation of flatus. These attacks are obviously due to twists which undergo spontaneous rectification.

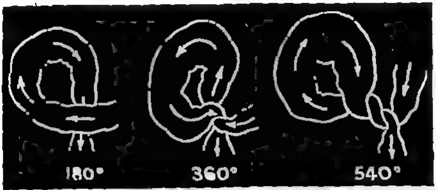

Fig. 620.—Various degrees of volvulus of the sigmoid colon. (*After Krol and Tabaka.*)

A Russian Jew, aged 27, was admitted with severe abdominal pain. His bowels had not moved for three days, but for him this was not an unusual occurrence. Examination of the abdomen showed a large resonant tumour arising from the left iliac fossa. An enema gave no result. The diagnosis of volvulus of the sigmoid seemed quite evident, and operation was advised. He took the anæsthetic badly. While struggling and shouting during the early stages of induction, he passed a quantity of flatus followed by a fluid motion. The anæsthetic was therefore discontinued. The resonant tumour disappeared. Next day he felt quite well, and refused to stay in hospital.

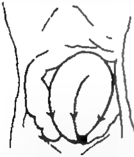

Fig. 621.—The Frimann Dahl sign. Three radio-opaque lines converging towards the stenosis are characteristic of volvulus of the sigmoid.

Fig. 622.—Unwinding a volvulus of the sigmoid.

The usual mental picture of volvulus of the sigmoid is one of very acute intestinal obstruction with a rapid and enormous abdominal distension—a distension so great that it may cause respiratory embarrassment. While the final attack conforms to this clinical concept, there are usually milder subacute attacks.

The Frimann Dahl radiographic sign is pathognomonic, and is often present. Haustral markings are absent because of the distension, and there is often tumour-like density corresponding to the ballooned sigmoid. Three dense lines converging towards the obstruction (*Fig.* 621) are often present, and are most convincing.

It is quite clear that volvulus of the sigmoid is a recurrent condition. A patient was operated upon for acute volvulus of the sigmoid on no less than four occasions (Barnard). Bloodgood reported a case in which there were 32 attacks or recurrences in one individual in the space of sixteen years.

Treatment of Acute Volvulus of the Sigmoid.—

Sigmoidoscopy and an endeavour to pass a rectal tube by its aid, is worth a trial in subacute cases. Even if this measure proves successful in relieving the obstruction, laparotomy should not be delayed more than a few days.

The abdomen is opened by a left lower paramedian incision, and the volvulus delivered. Using both hands (*Fig* 622) untwisting is attempted. When the pedicle can be seen the direction in which to rotate will be apparent: in other circumstances the method of trial must be employed, commencing in the clockwise direction. In cases of enormous distension it may be advisable to evacuate the gas before untwisting is completed. After a purse-string suture has been inserted the loop is punctured through one of the teniæ coli with a 17 S W G hollow needle. If the latter is used it is an advantage to have it connected to a suction apparatus. After deflation the purse-string suture is tied. As a rule puncture is unnecessary. *After appropriate rotation the gas can be evacuated per rectum*, especially when a rectal tube has been inserted in readiness before commencing the operation.

Fig 623.—The principles of the Paul-Mikulicz operation applied to volvulus of the pelvic colon.

To rest content with relieving the obstruction is in this *instance poor surgery. Not only is recurrence almost certain* at some future date, but there are other hazards.

In spite of increased abdominal distension and enemata yielding only blood-stained fluid, R S., aged 60 a business man hailing from *South-east Europe had little pain and steadfastly refused operation* for 48 hours. At last he was prevailed upon, on the understanding that nothing would be done that was not absolutely necessary. A spinal anæsthetic was administered. Sigmoidoscopy showed a bloody exudate in the upper rectum and it was impossible to pass the instrument farther. A rectal tube was inserted and left in position. Via a left lower paramedian incision the volvulus was untwisted, after which the rectal tube was manœuvred into the ballooned sigmoid. In spite of considerable meteorism, the abdomen was closed without difficulty. The tube was left in position, and rectal wash-outs were ordered. On the following day his general condition was excellent. After a further twenty four hours the abdominal distension returned, but an enema produced a good result. The pulse began to mount steadily and his condition deteriorated. Too late it was realized that the patient had general peritonitis. The fatal issue was due to a perforated diverticulum of the colon. Evidently the inflamed diverticulum was the apex of the volvulus, and manipulations or the rectal wash-outs had caused perforation.

As a result of this experience the addition of some form of colostomy in every case *of volvulus of the large intestine is advised. Undoubtedly volvulus of the sigmoid* is a condition *par excellence* for the Paul-Mikulicz operation (*Fig* 623)

Because of the frequency of paralytic ileus passing to a fatal termination in this condition, it is recommended that after anastomosing the limbs of the base of the pelvic colon one should resect the large mass of redundant large intestine on the following day or within 48 hours, and pass a soft rectal tube well into the proximal end of the bowel. In this way high and early suitable enemata can be administered.

The Rev N S. B., aged 59 walked into his doctor's consulting room complaining of intermittent colic and constipation of three days duration. For many years he had suffered from attacks of alternating diarrhœa and constipation, accompanied by abdominal distension. On examination the doctor found that although the patient's pulse and temperature were normal, his abdomen was immensely distended. Two hours later the abdominal distension was drum-like and because the left side of the abdomen was clearly more distended than the right a diagnosis of *volvulus of the pelvic colon was made. As his blood-pressure was comparatively low* a spinal anæsthetic was contra-indicated. A gastric aspiration tube was passed and the stomach was found to be empty. Under local anæsthetic supplemented with gas and oxygen, the abdomen was opened through a left split rectus incision. The pelvic colon was the size of a motor tyre. Two twists were unravelled with some difficulty owing to soft adhesions, which were broken with the finger. *After suitably isolating the loop and having introduced a purse-string suture* the intestine was punctured with a hollow needle. Gas hissed out. The opening in the gut was enlarged sufficiently to allow a soft rectal tube to be passed well up into the proximal bowel: this was stitched in place. The limbs of gut at the base of the redundant loop were joined together for 6 in., and the Paul Mikulicz technique was followed.

Although he remained in tolerably good condition, there was absolute constipation. On the fifth day the patient was taken to the operating theatre and the mass of prolapsed intestine was resected without anæsthesia. A full-sized rubber rectal tube having been passed into the proximal limb of the colostomy opening saline solution was gravitated into the bowel; bubbles of flatus were observed in the wash-out On the following day after an injection of pitressin, followed by an ox bile enema a copious fluid action of the bowels was obtained. The remainder of the progress of the case was uneventful, and the patient when seen a year later was in exceptionally good health.

Usually to undertake the resection earlier is advisable and it may spare a great deal of anxiety

Occasionally the gut is non viable down to the pelvirectal junction in which case not enough viable distal intestine remains to perform a Paul Mikulicz operation. In this instance resection should be followed by invagination of the lower short segment of the colon into the rectum, and by bringing out the upper end as a terminal colostomy

OBSTRUCTION OF THE LARGE INTESTINE BY GALL-STONE

Twenty-six cases of colonic obstruction due to a gall-stone have been reported in the literature. Considering that gall-stone ileus is a rare condition, this is actually a considerable number and it must be presumed that the incidence of colonic obstruction from gall stone ranges from 3 to 5 per cent of all cases of gall-stone ileus. Obviously in these cases the gall-stone does not reach the large intestine unheralded on the contrary all cases have typical intermittent intestinal obstruction, often of many days duration. Undoubtedly an essential factor in the development of intestinal obstruction is intestinal spasm around the gall-stone, and such spasm may very well occlude bowel around a stone which is not, in itself, large enough to block the lumen. Considerable meteorism, which is otherwise unusual in gall-stone ileus, is very often present. The intermittent course on which a pronounced intestinal obstruction is often superseded by a period of complete absence of symptoms and with the passage of both flatus and fæces, may easily beguile the surgeon into misinterpreting the condition as a subacute form of obstruction and taking an expectant attitude with delay that may prove fatal. The only way in which to improve the prognosis of gall-stone ileus is its earliest possible recognition, followed by prompt operation. In some cases it has been possible to push the stone onwards towards the rectum, from which it was removed by a finger passed through the anus. If this procedure is possible without much manipulation, it is justifiable otherwise enterotomy must be performed. It is never justifiable to push a gall-stone obstructing the ileum into the cæcum and leave it there. As long as the stone has not been removed, a recurrence of obstruction in the colon is possible.

MESENTERIC OCCLUSION AFFECTING THE LARGE INTESTINE

When the large intestine is the seat of the infarction the prognosis is very poor The pre-operative diagnosis is exceedingly difficult. Blood is likely to be passed per rectum. There is usually severe abdominal pain with rigidity and tenderness over the involved area. A barium enema will show an absence of obstruction.

The variety most amenable to treatment is that in which a segment of the transverse colon is involved (middle colic artery)

When the condition is due to mesenteric venous thrombosis, as opposed to arterial occlusion, and the gut is severely congested but not gangrenous, exteriorization is recommended. Should exteriorization of the congested portion prove to be *impracticable*, Morgan Williams advises, and has had success with, expectant treatment, which includes the administration of anticoagulants.

Infarction of the Transverse Colon.—Resect the gangrenous area widely Do not attempt primary anastomosis. Exteriorize both the proximal and the distal cut ends of the colon through suitable short incisions.

Infarction of the Right Half of the Colon.—Resect the cæcum and ascending colon as far as necessary Perform ileocolostomy

Infarction of the Left Half of the Colon, which is exceedingly rare, sometimes allows a Paul Mikulicz operation to be performed. If not, resection of the affected portion, with insertion of a Paul's tube into each end of the remaining colon, may permit later

reconstruction. Failing this, the lower end should be invaginated and the upper end brought out as a terminal colostomy. At a later stage the continuity of the bowel can be restored.

ACUTE INTESTINAL OBSTRUCTION DUE TO PATHOLOGICAL CONDITIONS OF THE RECTUM

The causes of acute obstruction so far as the rectum is concerned may be summarised as follows:—

(1) Malignant disease. (2) Impaction of fæces. (3) Simple stricture of the rectum. (4) Obturation by gall-stone, stercolith, or foreign body.

1. **Malignant Disease.**—If malignant disease has proceeded so far as to cause acute intestinal obstruction, the growth is nearly always inoperable, and a left inguinal colostomy is indicated. An exception to the rule is a ring carcinoma of the rectosigmoidal junction, which causes obstructive symptoms comparatively early. In this type of case the obstruction may sometimes be relieved by passing a rectal tube through the sigmoidoscope. If the rectal tube can be insinuated through the stricture, it is anchored to the anus by a stitch. It can be left in place several days, and allows the colon to be washed out, an excellent preparatory treatment for an operation designed to remove the growth, should it prove operable when the abdomen has been opened. If the rectal tube cannot be made to pass the obstruction, transverse colostomy is indicated.

2. **Fæcal Impaction.**—The disimpaction of fæces is a necessary but most distasteful surgical task. Many of these patients have a fissure-in-ano, and as it is necessary to stretch the sphincter thoroughly in order to remove the accumulation, the fissure (which is probably the starting point of the vicious circle) is often remedied at the same time by the stretching. A teaspoon, a dessertspoon, and sponge-holding forceps, used in that order, are the best instruments with which to remove the mass.

Fig. 624.—Gall-stone which caused obstruction, removed from the rectum. (× ½)

3. **Simple Stricture of the Rectum.**—

E. W., a girl of 17, was admitted with acute intestinal obstruction. For eight years she had suffered from severe constipation; the bowels rarely moved without purgatives. For the past fourteen days she had been in much pain and had vomited repeatedly. The constipation had continued throughout all this period in spite of enemata and purgatives. Examination showed drum-like distension of the abdomen, and she was obviously very ill. The pulse rate was 132 and the temperature subnormal. Two inches (5 cm.) within the anal canal a tight stricture could be felt which just admitted the tip of the finger. Under spinal anæsthesia the stricture was stretched so as to admit four fingers. Fæces were removed. Enemata produced copious results for some days. Recovery.

This must have been congenital—a semi-imperforate anus. More often the stricture is inflammatory.

It is important to arrange for a periodic dilatation of a stricture after the patient has been discharged.

4. **Impaction of Foreign Bodies.**—

Stercolith in the Rectum.—

An old woman, 72 years of age, was admitted with acute-on-chronic intestinal obstruction. The abdomen was greatly distended and the cæcum hyper-resonant. A hard body could be felt in the rectum. Under anæsthesia the sphincter was stretched, and liquid fæces poured forth. An attempt was made to grasp the body with the forceps which are used to introduce Champetier de Ribes' bag, but this was not successful. Eventually the body was delivered grasped between a scoop and the index finger of the left hand, and was found to be a stone-like body the size of a tangerine orange (the nucleus may have been a gall-stone). Recovery.

For delivery of a foreign body of this character a dessertspoon would have been a very useful instrument.

Gall-stone in the Rectum.—

A man of 57 was admitted with subacute intestinal obstruction, which responded to enemata. A year before the patient had been under treatment for gall-stone colic accompanied by jaundice

but he had refused operative treatment. It was therefore reasonable to conclude that the body which was felt was a gall-stone. The next day a sigmoidoscope was introduced and the body was seen, but with the air inflation it moved farther and farther up the colon, and was quite out of reach. A gridiron incision was therefore made in the left iliac fossa and the stone was pushed down into the rectum, where it was delivered by an assistant. The stone is shown in *Fig* 024 The gall-bladder contained one very large calculus, but as the condition of the patient was poor this was not removed.

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CHAPTER XL

PARALYTIC ILEUS (ADYNAMIC ILEUS)

No condition gives rise to more anxiety than paralytic ileus. First and foremost, there is the difficulty of being sure of the diagnosis. To emphasize the magnitude of the subject at the Royal Adelaide Hospital, South Australia, paralytic ileus accounted for death in 10 out of 1000 post mortem examinations (Devine). Although deeply rooted, the name paralytic ileus is perhaps ill chosen, for the intestine is not paralysed but inhibited, apparently from overacting sympathetic influences. In the majority of cases it is the ileum that is first affected—hence the term.

Paralytic ileus often follows major abdominal operations. It is also frequently encountered after operations for diffuse or pelvic peritonitis. In peritonitis plastic adhesions between the coils of ileum also play a part. When peristalsis is enfeebled, 'bread and butter adhesions' become obstacles. Ileus following peritonitis may therefore be partially paralytic, but is often at least partially mechanical. Noble pleads that in cases of ileus following operation for peritonitis in general, and appendicitis in particular, the current conception that paralytic ileus is common does much harm. Most of these cases unrelieved by gastro-intestinal suction for 24 hours are due to mechanical obstruction. It should be ever before one, especially in cases of appendicitis, that distension and obstructive symptoms commencing *within the first three days* after operation are usually due to paralytic ileus. True intestinal obstruction usually comes on *between the sixth and tenth* day, but it is sometimes supremely difficult to decide which of these two conditions is present.

Devine is of the opinion that the most frequent cause of paralytic ileus is some degree of post-operative intraperitoneal infection.

Reflex Paralytic Ileus is less common than the post-operative variety. It occurs in a number of heterogeneous extraperitoneal conditions that include retroperitoneal hæmatoma, renal and (less frequently) biliary colic, torsion of the testis, fractured ribs, fractured spine, fractured femur, and the application of a plaster jacket in hyper-extension.

Paralytic Ileus of Uræmia.—Abdominal distension, hiccup, and vomiting are frequent accompaniments of advanced uræmia.

Diagnosis of Paralytic Ileus. Paralytic ileus usually comes on rapidly. At first distension is most apparent below the level of the umbilicus, but as the condition progresses the whole abdomen becomes involved, by which time breathing is mainly of the costal type and is increased in frequency. The pulse-rate rises. The patient experiences no pain, but sometimes complains of discomfort due to the distension. He frequently has no conception of the gravity of his condition. Thirst is a regular symptom. If the unintubed patient is allowed to satisfy it, the liquid ingested is regurgitated effortlessly. The abdomen is slightly tender, and always tympanitic. On auscultation the abdomen is silent, or almost so. In established cases no borborygmi are heard. Later, when the condition has been present for 48 hours or more, feeble noises unconnected with peristalsis are present; there are the soft murmurs occasioned by excursions of the diaphragm setting in motion the fluid within the bowel, there are the heart-sounds, and sometimes the breath-sounds—all these are often heard when there is a considerable amount of fluid in the bowel and the peritoneal cavity, fluid is a good resonator. An enema is partially expelled, perhaps with a little fæcal matter; sometimes it is retained. In severe cases the abdomen becomes tense and drum-like, the pulse-rate rises steadily, and dyspnœa with cyanosis is present. Delirium and coma sometimes supervene, in which case the prognosis is exceedingly poor.

Radiology.—Moderately distended gas-filled small intestine is seen in the centre of the abdomen. The presence of gas in the small *and the large* intestine is characteristic of paralytic ileus. Myriads of bubbles of gas in the small intestine, giving a mosaic appearance, are typical of this condition.

Pathology.—There is a large amount of gas and fluid throughout the whole intestine. Distension of the intestine causes pressure on the veins that encircle the ileum (*Fig.* 625).

This interferes with the absorption of gas and fluid, and leads to more distension. Another local effect of distension is that, of itself it can cause partial obstruction by kinking of the distended small intestine at the apex of the coils (*Fig* 626)

Prophylaxis in paralytic ileus is not always possible, but its incidence can be reduced by —

1 The avoidance of pre-operative purgation

2. By gentle handling and careful hæmostasis during operation.

3 The substitution of pethidine (100 mg intramuscularly) or amidone (10 mg intramuscularly) dose for morphine and its derivatives which, especially if repeated, are likely to inhibit normal intestinal propulsion, and may cause segmental tonic contraction of the small intestine (Stretten and McQuaid)

4 By giving all fluids parenterally for 48 hours after major abdominal operations, or until the patient has passed flatus.

5. In view of the fact that 68 per cent of gas in the intestine[1] is derived from swallowed air early post-operative gastric aspiration is a great preventive of paralytic ileus. In those cases where paralytic ileus is anticipated, the passage of a Miller Abbott tube pre-operatively at operation, or immediately after operation, and the application of continuous suction to the tube, greatly minimizes the incidence of paralytic ileus.

Fig. 625 — The increasing distension causes pressure on veins, and interferes with absorption. (*After J Devine*)

Fig 626. —Partial obstruction occurs at either end of greatly distended coils by reason of the distension. (*After J Devine*)

Treatment: Methods to avoid.—

1 *Drugs, particularly the repeated administration of drugs scheduled as peristaltic stimulants*[2] are extremely dangerous, and they jeopardise more lives than they save. These preparations include physostigmine (eserine), prostigmine, neostigmine pituitrin, pitressin, carbachol, esmodil and acetylcholine Acetylcholine, being Nature s detonator between the nerve synapses and the intestinal musculature, appeared to me to be particularly alluring, until the following disaster occurred —

Mrs. D had a gangrenous, twisted ovarian cyst, which was removed at a cottage hospital. Forty-eight hours later she was a little distended and there had been no result from an enema. Her general condition was excellent and there appeared no cause for anxiety Masterly inactivity was advised, but those in attendance seemed disappointed and wanted a peristaltic stimulant prescribed. By way of a compromise it was suggested that acetylcholine could do no harm. Eight hours later the clinical picture had changed completely The abdomen was drum-like the patient looked ill, and the pulse had risen 28 points. A gastric aspiration tube was passed and continuous intravenous saline solution was administered. Three hours later the pulse was a little stronger but there was no substantial improvement In spite of negative auscultatory evidence I feared mechanical obstruction and re-opened the abdomen under spinal anæsthesia. There was no mechanical obstruction. The coils of ileum were the size of a motor bicycle inner tube. I performed enterostomy The enterostomy tube failed to function and the patient died within twenty four hours.

This case is not unique Acetylcholine sometimes has the opposite effect to that desired, viz. irreversible intestinal paresis.

When contemplating giving a peristaltic stimulant in paralytic ileus it must be realized that the gut has already received its normal stimulus—to wit, distension—in excess, and has not responded. All measures that stimulate peristalsis are bound to act most effectively on the comparatively normal upper coils of jejunum. Whether these stimulants have any action on the paralysed intestine below (*Fig* 627) is questionable Their effect is to force more fluid into the cesspool near the ileocæcal valve (*H W L. Molesworth*)

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[1] In non-strangulating obstruction the derivation of the gas is as follows: 68 per cent is due to swallowed air 22 per cent to diffusion into the bowel lumen of gases from the blood-stream, and 10 per cent to bacterial decomposition of the intestinal contents (Hibbard). In closed-loop obstructions the gas must be derived entirely from the latter two sources. Whatever its original composition, the oxygen is quickly absorbed into the blood-stream and the gas becomes composed of about 90 per cent nitrogen, the remainder being carbon dioxide and hydrogen sulphide

[2] Successes attributable to these drugs are far outnumbered by the majority of cases in which the patient is made worse by such treatment (R. L. Holt).

2. *Do not apply heat to the abdomen*, e.g., turpentine stupes. Heat has no effect whatever on peristalsis, but it often blisters the abdominal wall.

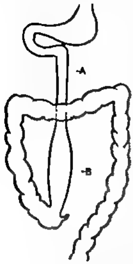

Fig. 627.—Diagram showing the mechanism of failure of the treatment of paralytic ileus by exciting peristalsis. A, Comparatively healthy small intestine readily excited by purgatives; B, Paralysed intestine inexcitable by peristaltic stimulants. (*After H. B. L. Molesworth.*)

3. *Repeated enemata are to be avoided.* One enema every 48 hours, for diagnostic purposes, is permissible. Some favour the retention of a flatus tube. An indwelling flatus tube tends to curl up in the ampulla of the rectum and deflates only that region. Because of the discomfort it causes, the indwelling flatus tube is not recommended.

4. *Inhalation of oxygen in high concentration* (95 per cent) is said to be beneficial, provided it is continued for more than 24 hours. By preventing atmospheric nitrogen from entering the lungs, the body tissues, including the intestinal mucous membrane, pour forth their free nitrogen into the lungs via the blood-stream. The danger of intensive oxygen therapy is pulmonary œdema and massive collapse of the lungs. It should be reserved for patients who are cyanotic.

5. *Enterostomy is of little or no value.* It drains only a short segment on either side of the catheter.

Management and Treatment.—Increase or decrease of the girth of the abdomen at the level of the umbilicus, measured with a tape-measure left in position, should be recorded four hourly.

The passage of a Miller Abbott tube through the pylorus is a most gratifying event. In most instances it is the harbinger of comparatively early resumption of at least some degree of peristaltic activity. Actually the Cantor tube, with its smaller mercury loaded bag, is less likely to be held up by the pyloric sphincter. Successful intubation confers immeasurable benefit, both symptomatic and actual. However, in paralytic ileus the descent of a balloon-ended intestinal tube even into the upper reaches of the jejunum is unusually slow. The amount of fluid aspirated in paralytic ileus is comparatively small ($\frac{1}{2}$ l. per day) when compared with that of mechanical obstruction ($1\frac{1}{2}$ l.). Five to seven days are often required to complete the decompression in severe cases of paralytic ileus. In practice it is found that a balloon-ended intestinal tube fails to pass through the pylorus in those cases where decompression is most necessary, in which case it is often advisable to resort to operative pre-pyloric intubation (see p. 200).

The intestinal tube must be left in place until the patient has passed flatus, and measurements and radiographs show decreased distension.

Maintenance of fluid and electrolytic balance is the breath of life in the condition under consideration. It should be borne in mind that hypochloræmia, hypokalæmia and hypoproteinæmia all severely aggravate paralytic ileus. Each must receive due diagnostic consideration, and if one or more is present the deficiency must be rectified. It should be noted that a patient with paralytic ileus, because of depressed renal function, becomes hydrated easily. To substitute 1 litre of plasma for electrolytic fluid therapy during part of the day helps to guard against overhydration, and in cases of some standing supplies much needed protein. In patients suffering from hypoproteinæmia, following plasma infusion peristaltic movements sometimes recommence.

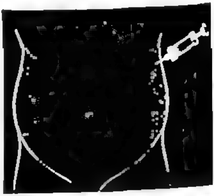

Fig. 628.—Procaine block of the abdominal wall.

Cajuput Oil 1 min. (0.06 ml.) may be ordered to help the patient to pass flatus, and this can be repeated. It is sometimes effective.

Antibiotic therapy: When paralytic ileus is due to bacterial peritonitis antibiotic treatment is mandatory. In other cases, seeing that an infected element cannot be excluded, antibiotic treatment can only do good.

Pantothenic acid. Not being a direct parasympathetic stimulant, the administration of this vitamin, which is necessary for the elaboration of acetylcholine, is permissible. Jacques finds that it often terminates the paresis. It is given intramuscularly in

the form of its soluble calcium salt, calcium pantothenate 50 mg. This can be repeated in 6 hours, if required.

An ice-bag. Although contrary to current practice an ice-bag applied to the abdominal wall normally excites peristalsis, and sometimes, in early paralytic ileus, this measure results in gas being expelled per rectum.

The intermittent passage of a flatus tube may be helpful. A flatus tube with a terminal eye is the best pattern to employ. Once even a little flatus has been passed, an ox-gall enema is often effective.

Procaine block. Novikov injects between 30 and 70 ml. of ½ per cent procaine into a posterior part of the abdominal wall (*Fig.* 628) in order to obtain a bilateral nerve-block. When the ileus is dynamic, the patient often passes flatus in half to one hour. In other cases this happy result follows an enema at the expiration of one hour. Novikov states that the method is effective in 55 per cent of cases.

PARALYTIC ILEUS AFFECTING MAINLY THE LARGE INTESTINE

This is rare and appears to be associated particularly with operations upon the lower urinary tract, e.g., prostatectomy, partial cystectomy.

Leiter and Lyons Case.—

The patient was a man aged 67 who, following an operation for suprapubic implantation of radon seeds, developed paralytic ileus affecting the large, as well as the small, intestine. In spite of the usual methods of treatment the condition persisted without remission. On the twelfth day cæcostomy was performed under local anæsthesia, with striking improvement. Recovery.

Cæcostomy is justifiable when the balloon-tipped catheter remains stationary near the duodenojejunal junction and radiography shows the cæcum ballooned. Wangensteen has employed cæcostomy effectively in two refractory cases fulfilling these indications.

THE DIFFERENTIAL DIAGNOSIS BETWEEN POST-OPERATIVE INTESTINAL OBSTRUCTION AND PARALYTIC ILEUS

The differential diagnosis between post-operative intestinal obstruction and paralytic ileus can be supremely difficult for, as is well known, both may be present. On the one hand the added insult of re-opening the abdomen of a patient who is suffering from paralytic ileus may so aggravate the condition as to cause some intestinal atony to become irreversible, and ultimately fatal. On the other hand, failure to operate upon a patient with mechanical obstruction, and to relieve that obstruction, is fatal even more often. According to circumstances, one has between 4 and 30 hours to arrive at this all-important diagnosis, during which time the patient should be visited 4-hourly.

The mainstays at arriving at a decision are as follows:—

1. A patient with pure paralytic ileus at no time suffers from intestinal colic.

2. In paralytic ileus repeated radiographs show gas in the large, as well as the small, intestine.

3. After 24 hours of continuous intestinal aspiration the dual test is applied. The tube is clipped for 2–4 hours, suction being discontinued. If the patient has intestinal obstruction it is probable that he will experience rhythmic pain. After suction has been resumed for half an hour the patient is given ½ pt. (280 ml.) of water to drink slowly. If a considerably greater quantity than ½ pt. is withdrawn within half an hour it is highly probable that mechanical obstruction is present.

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CHAPTER XLI

INTESTINAL OBSTRUCTION IN THE NEWBORN

When a newborn baby continues to vomit there are only three explanations—intracranial hæmorrhage, severe infection (e.g., omphalitis) and intestinal obstruction. What a pity it is that the last condition so frequently remains undiagnosed for a number of days, for the various lesions that cause it are often supremely remediable. A factor encouraging delay is the apparent fitness of the infant with intestinal obstruction during the first 48 hours of life: this is accounted for by the fact that unless the loss of fluid and electrolytes is considerable the newborn babe lives on its own resources until the maternal flow of real milk is established.

Vomiting.—During the first 36 hours of life, 90 per cent of babies vomit swallowed amniotic fluid, vaginal secretion, and blood. Exceptionally a normal infant vomits yellow material, the colour being due to the presence of carotene pigments in the colostrum milk. On the other hand, bile-stained vomiting[1] in the neonate spells intestinal obstruction.

Distension is difficult to assess in the naturally protuberant abdomen of the newborn. Fullness of the abdomen at birth suggests intestinal obstruction arising in utero. It is, however, also found in distension of the bladder (due to urethral obstruction), congenital cystic kidneys or liver, abdominal tumours, fœtal ascites, and in meconium peritonitis. In all of these, except the last, some part of the abdomen is dull to percussion. Distension due to intestinal obstruction may be localized to the epigastrium when the obstruction is of the duodenum, or generalized. In the latter case the abdomen soon becomes tense and shiny, displaying dilated veins beneath the skin. In obstruction to the ileum the *distension is central. When the lower colon is obstructed the distension is* gross, obvious in the flanks, and accompanied by undue protuberance of the costal margins. A child born with abdominal distension should not be fed until the diagnosis is established.

Peristalsis is sometimes visible.

Meconium, black, and of tarry stickiness, is generally passed during the first few hours after birth. In normal infants, on the third or fourth day of life meconium gives place to stools showing the presence of milk curds. The passage of meconium during the first three days of life does not negative a diagnosis of intestinal obstruction.

Sudden deterioration of the infant usually coincides with commencing gangrene of the intestine: the chemical imbalance resulting therefrom causes instability of the respiratory centre and early exodus from collapse of the lungs or weakening of the cough reflex, which permits inhalation of gastric contents, and inevitable pneumonia.

Radiography.—Babies swallow two to three times as much air as fluid during a feed. Within two hours after birth air enters the small intestine. By six hours the transverse and descending colon is filled, but the time of filling of the sigmoid and rectum is inconstant. In 82 per cent of cases air can be demonstrated in the sigmoid at six hours, but in only 2 per cent at eight hours. It is concluded that flatus is passed per rectum, and it takes time *for air to reaccumulate. It is important to have films with the patient* held in an erect posture in addition to the more usual supine films. A plain radiograph will not only assist in demonstrating the presence of intestinal obstruction, but in 70 per cent of cases it reveals the site of that obstruction with considerable clarity. It must be understood that in an infant the radiological appearances of the jejunum, ileum and colon all have the same smooth outline, and that normally a few fluid levels are present. The essential findings in small-bowel obstruction are considerable air distension of coils of intestine and an abrupt termination of the distension at the site of the obstruction—but unless a number of fluid levels are seen in addition, obstruction cannot be diagnosed with certainty. Colonic obstruction can be differentiated from small-bowel obstruction because the dilated colon shows as a gas-filled structure lying in the flanks and running across the epigastrium. If there is doubt as to the identification of distended small intestine, a small amount of barium emulsion can be run into the rectum. In small bowel obstruction the colon will be seen as a thin thread

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[1] Of 4000 newborn babies only 2 instances of bile-stained vomit occurred in the absence of mechanical obstruction (H. H. Nixon).

running around the abdomen. However this microcolon (which is only the size of a lead pencil, owing to the fact that no intestinal contents have ever entered it) is very liable to fail to admit barium emulsion, thus giving a fallacious picture suggesting colonic obstruction.

Pre-operative Preparation is of signal benefit to these miniature but remarkably responsive, patients.

Gastric Aspiration.—The best gastric aspiration tube for the neonate is a No. 8 or No. 10 soft rubber catheter with several additional holes cut near its distal end. Even a plastic tube left in contact with the pharynx of a newborn infant is liable to set up inflammation that culminates in acute œdema of the glottis. It is therefore wise to avoid an indwelling tube, and effect deflation of the stomach by passing the catheter into the stomach every three hours, emptying the stomach and withdrawing the tube. When possible radiography should be undertaken before and after the first gastric aspiration.

Fluid Therapy.—Dextrose-saline is usually given unless the electrolytic depletion is severe, when half-strength Darrow's solution and 5 per cent dextrose in equal parts will not supply too much sodium chloride in proportion to other salts. The intravenous route is best but the subcutaneous route with hyaluronidase in early cases, may suffice. Exceptionally when dehydration is severe and a suitable vein cannot be found, infusion into the bone-marrow is most serviceable. In all cases a specimen of blood should be sent for cross-matching. During the operation plasma or blood should be given.

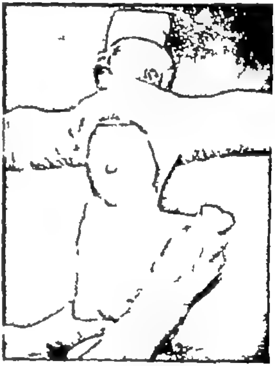

Fig. 629.—The padded crucifix in use.

Antibiotic Therapy.—Penicillin (30 000 units per 24 hours) and streptomycin (10 mg. per lb. of body weight per 24 hours) intramuscularly are effective. Because of the thrombosis they engender intravenous antibiotics should be avoided.

Vitamin K.—2.5 mg. subcutaneously to counteract an undue hæmorrhagic tendency is advisable. One dose before, and one dose after operation usually suffice.

Anæsthesia.—Probably the safest but by no means the most satisfactory is local infiltration with oral sedation which can take the form of dextrose water and brandy given by a bottle with a nipple. When local anæsthesia is employed some form of restraint is necessary; the best method is to bandage the wool covered extremities firmly to a padded crucifix (*Fig.* 629).

General anæsthesia administered by an anæsthetist experienced in anæsthetizing infants (who are most susceptible to post-endotracheal œdema of the glottis) by providing relaxation of the abdominal wall simplifies the surgeon's task. Endotracheal anæsthesia provides a free airway in the presence of an unstable respiratory centre, and prevents inhalation of gastric contents. Scoline as a muscle relaxant is safe to use in infants, and provides wonderful muscular relaxation.

CONGENITAL ATRESIA[1] AND STENOSIS[2]

Congenital atresia and stenosis are the commonest causes of neonatal obstruction of the small intestine; one or other occurs once in 20 000 births. The site of the obstruction is as follows:—

Duodenum above the papilla	15 per cent	33 per cent
Duodenum below the papilla	18 ,,	
Jejunum	15 ,, ,,	
Ileum	25 ,, ,,	
Colon (usually ascending colon)	10 ,, ,,	
Multiple sites	17 ,, ,,	

(*Davis and Poynter*)

[1] Atresia—imperforation.
[2] Stenosis—narrowing or stricture.

The high incidence of multiple sites calls for examination of the whole of the small intestine and the ascending colon at operation.

ATRESIA AND STENOSIS OF THE DUODENUM

Unless the obstruction is partial, persistent vomiting occurs from birth. The vomitus is bile-stained, except in those cases where the septum lies above the duodenal papilla, in which case the vomitus consists of gastric contents only; consequently the diagnosis is likely to be made late. Abdominal distension is not pronounced; indeed, it is often absent. Visible peristalsis is sometimes seen passing from left to right. Atresia and stenosis occur with about equal frequency. In many cases of stenosis there is a tiny hole that allows only the passage of gas. In 25 per cent of cases the orifice is large enough for small amounts of intestinal contents to pass intermittently, but insufficient for continued survival. One or more meconium stools are passed by 33 per cent of patients with duodenal atresia.

Fig. 630.—Duodenal atresia, showing air in the stomach and duodenum in contrast to the absence of gas shadows in the rest of the abdomen. (*J. Swain.*)

Radiography.—A plain film is often all that is necessary to make the diagnosis. Before gastric aspiration, the stomach and upper part of the duodenum are grossly distended with air (*Fig.* 630); after gastric aspiration the shadow largely disappears. Usually there is an absence of, or less than normal, gas shadows in the rest of the alimentary tract. There is no justification for giving a barium meal: the danger of aspirating vomitus is too great. When it is absolutely necessary to give opaque material (partial obstruction) a small amount of lipiodol given through the gastric tube is useful for demonstrating the location of the obstruction, but the opaque material should be aspirated directly after the films have been exposed.

Differential Diagnosis.—Suprapapillary duodenal atresia is distinguished from oesophageal atresia (p. 738) by the fact that there is no dribbling of saliva and no attacks of cyanosis after feeding. The absence of a palpable lump serves to differentiate duodenal obstruction from infantile pyloric stenosis.

The surgeon must remind himself that duodenal obstruction in infancy can also be caused by volvulus of the midgut (p. 473), congenital bands (p. 471), and an annular pancreas.

Lastly, attention is directed to the high incidence of mongolism amongst sufferers from duodenal atresia and stenosis. For a reason as yet obscure, mongolism is linked only with duodenal obstruction due to atresia or stenosis. If signs of mongolism are apparent in the neonate (they are sometimes delayed until the infant is older) surgical rectification becomes a matter for ethical consideration.

Pre-operative Treatment.—Duodenal atresia and stenosis demand early diagnosis, prompt replacement of fluids and electrolytes, gastric suction, antibiotics, and blood transfusion when indicated. Operation should be carried out as soon as dehydration has been combated.

Operation.—Duodenojejunostomy (*Fig.* 631) is the operation of choice. The mortality has been reduced by the following small addition to the operation. After completing the anastomosis, a stab incision is made through the wall of the pyloric antrum. Through this incision a rubber catheter is passed, and its tip is guided through the anastomosis. The tube is anchored to the stomach wall by a catgut stitch, and a valvular opening is constructed, using the technique illustrated in *Fig.* 380, p. 304. The tube is brought to the surface either through a stab incision or through the upper part of the laparotomy incision, whichever gives the more direct passage. This additional step (*Fig.* 632) allows rest to the duodenum until its muscle tone has recovered, when milk feeding can be commenced

through the tube. Gastrojejunostomy has been followed by a number of successes, but there is always the likelihood of symptoms arising from food passing into the first part of the duodenum, from which its only means of escape is by regurgitation into the stomach.

Fig. 631.—Duodenojejunostomy completed for the relief of (inset) congenital septal duodenal obstruction in the 3rd portion of the duodenum. (*After W. E. Ladd.*)

Fig. 632.—Gastrostomy and passage of a catheter through the duodenojejunostomy. (*After G. H. McNab.*)

JEJUNAL AND ILEAL ATRESIA AND STENOSIS

In cases of atresia of the ileum central distension of the abdomen is usually obvious at birth, or soon after. Unfortunately vomiting is delayed for two or three days in 20 per cent of cases of ileal atresia, and in 30 per cent of incomplete intestinal stenosis up to two weeks (J. H. Louw). In cases of atresia the blind end of the intestine is always grossly dilated, and increased intraluminar pressure is so great as to cause anoxia of the intestinal wall, which may progress to gangrene and perforation—hence the urgency of this condition. Forty per cent of infants suffering from intestinal atresia pass meconium stools.

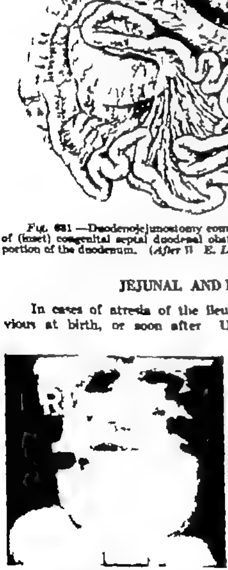

Fig. 633.—Intestinal obstruction due to atresia of the ileum, showing multiple fluid levels. (*J. H. Louw.*)

Radiology.—Obstruction of the small intestine cannot be diagnosed by radiology unless fluid levels are seen in addition to distended coils. By the time fluid levels are present the obstruction is in an advanced stage (*Fig.* 633). Occasionally radiographs in the upside-down position delineate the distal collection of air more clearly and serve to differentiate the condition from meconium ileus.

Operation.—If a collapsed loop is identified and followed upwards, the site of obstruction[1] (*Fig* 634) will soon be found. The results of short-circuiting operations (ileo-ileostomy or ileo-colostomy) are very bad.

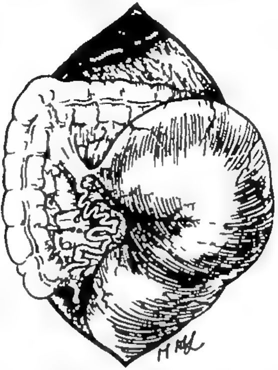

Fig. 634.—Intestinal obstruction due to atresia of the ileum. (*J. Swain.*)

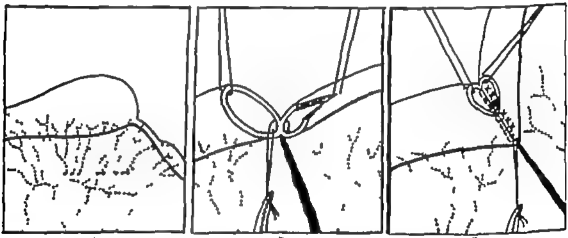

Fig 635.—The technique of end-to-back anastomosis. (*After Denis Browne.*)

Method 1.—End to-back anastomosis is performed as shown in *Fig* 635. From 12 to 25 cm. of intestine is resected and the proximal bowel sucked clear of contents, which would otherwise tend to inspissate and block the anastomosis. The distal bowel is inflated with saline solution to clear it of any concretions and to exclude the possibility of another atresia. Anastomosis is then performed with one layer of interrupted No. 00000 silk mattress sutures (preferably on atraumatic needles). The proximal bowel is cut sufficiently obliquely to make the opening 2 cm. long. The distal bowel is cut along its antimesenteric border for a like distance. The bowel is controlled by stay sutures; no clamps are used.

[1] In cases of apparent stenosis the possibility of aganglionic functional obstruction of the ileum should be borne in mind.

Resection with immediate anastomosis is indicated without hesitation in cases of jejunal obstruction and multiple occlusions involving a large segment.

Method 2.—The Paul Mikulicz procedure is less difficult to perform and avoids the danger of leakage. In cases where the obstruction lies in the ileum the results of this operation, performed early, are good. The two limbs must be sewn together with interrupted sutures of fine silk. The distal limb is so small that only a single row of stitches can be inserted. As the limbs are made to emerge from the abdominal wound (*Fig* 636) they should be anchored to the peritoneal edge by black silk sutures; when the time comes for closure of the enterostomy the dissection can then be carried down to these sutures, thus avoiding entering the abdominal cavity. After the abdominal incision has been closed a small Paul's tube is tied into the proximal limb and a catheter is stitched into the distal limb. A few days later these tubes are removed, and a crushing clamp is applied to the septum. Shortly after the clamp has destroyed the septum by pressure necrosis, a proportion of the intestinal stream passes along the alimentary tract, permitting some absorption of products of digestion.

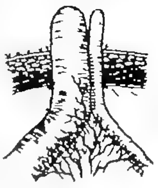

Fig 636.—Spur enterostomy in atresia of the ileum. (*After G H McNab*.)

Prognosis.—The mortality is still formidable, deterioration in the post-operative period being common. Success can be obtained only if operation is undertaken early, i.e., within 48 hours.

ABNORMALITIES OF ROTATION

The midgut re-enters the abdominal cavity during the tenth week of fœtal life. Usually the proximal part of the gut is the first to return, and it does so by passing behind the mesenteric vessels (*Fig* 637). This completed, the intra-abdominal arrangement of the intestines is as depicted in *Fig* 639; the cæcum is still suspended by a mesentery and has not descended. Alternatively, but much less commonly, the sequence of return of the midgut to the abdomen is reversed, the cæcum and ascending colon being the first to re-enter (*Fig* 638).

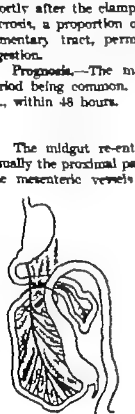

Fig 637.—Normally the pre-arterial coil of the midgut is the first to re enter the abdomen, and it does so by passing behind the superior mesenteric vessels.

Arrested Rotation.—The cæcum remains in the right hypochondrium, and a peritoneal band is found running from the cæcum (and sometimes the ascending colon also) to the right side of the abdomen across the second part of the duodenum; this is the transduodenal band of Ladd (*Fig* 640), which often produces duodenal obstruction in the newborn, either on its own account or, as will be seen, in association with volvulus of the midgut. Pressure on the duodenum can be relieved immediately by dividing the attachment of the band to the parietal peritoneum on the right side of the second part of the duodenum (*Fig* 641). After this band has been divided and the right half of the colon is displaced to the left the duodenum will be seen coursing downwards to join the jejunum. There is often a second peritoneal band—probably a misplaced ligament of Treitz—extending from the middle line to the commencement of the jejunum (*Fig* 642). If present, it is important to divide this second band, lest the obstruction persists. Sometimes a third band running from the terminal ileum to the ascending colon (*Fig* 644) is present also, and must be severed.

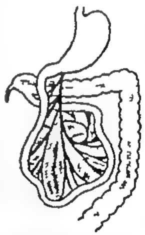

Fig. 638.—Reversed rotation. The post arterial coil has returned to the abdomen first. (*A Jeffreys.*)

The cæcum, now being free, is placed in the left side of the abdomen (*Fig* 643). It is far preferable to have the colon on the left side than to attempt to establish normal anatomical arrangement by fixing the cæcum in the right lower quadrant. The result of timely operation in these cases is excellent.

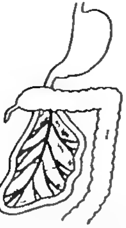

Fig. 639.—The disposition of the viscera soon after the midgut has returned to the abdomen. In arrested rotation this relationship is maintained. (After A. Jeffreys.)

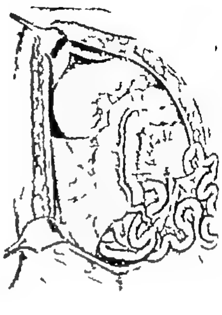

Fig. 640.—The transduodenal band of Ladd obstructing the duodenum.

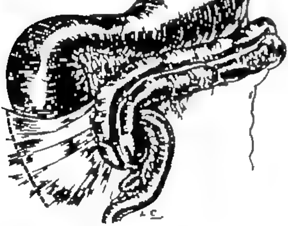

Fig. 641.—Site of severance of the transduodenal band. (After W. E. Ladd.)

Fig. 642.—Misplaced ligament of Treitz. (After H. H. Nixon.)

Fig. 643.—Replacement. The cæcum and ascending colon, being freed of all bands, they are deposited to the left side of the abdomen.

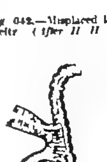

Fig. 644.—The ileocolic band. (After H. H. Nixon.)

VOLVULUS OF THE MIDGUT

VOLVULUS NEONATORUM

(*Syn.* VOLVULUS NEONATORUM)

Predisposing Causes.—Arrested normal intra-abdominal rotation (third-stage rotation) predisposes to volvulus of the midgut. The cæcum, suspended by a mesentery together with the whole of the small gut (the mesentery of which has a narrow attachment) revolves in a clockwise direction. Reversed rotation also predisposes to volvulus.

Diagnosis.—Vomiting is the leading feature and because the obstruction is low in the duodenum, the vomitus usually contains bile. Abdominal distension usually follows; at first it is limited to the epigastrium. Dehydration and electrolytic depletion can occur rapidly because of the copious vomiting of bile and pancreatic and gastric secretions.

Radiography.—A plain film will show dilatation of the stomach and duodenum (*Fig.* 645). A barium enema may show the cæcum in the right upper quadrant, which serves to distinguish the condition from duodenal stenosis or atresia which otherwise is hardly possible before laparotomy.

Fig. 645.—Gas shadows in the stomach and duodenum in a case of volvulus of the midgut. (*A. Jolleys.*)

Fig. 646.—Volvulus of the midgut. (*After Ladd and Gross.*)

Laparotomy.—If, on opening the abdomen, only distended coils of small intestine (which may be congested or cyanotic) and the stomach are seen, and it is impossible to view the right half of the colon, the surgeon should at once suspect volvulus of the midgut. The whole of the midgut must be delivered onto the surface where the intestine is protected with warm, moist abdominal packs. Only after this step has been taken is it possible to recognise the volvulus (*Fig.* 646) which usually takes place in a clockwise direction. The tightness of the twist is of greater importance than the number of turns. When the artery becomes occluded by the torsion the involved intestine rapidly becomes gangrenous, and pronounced shock and rapid death result. Reduction is effected by unwinding in the appropriate (usually anticlockwise) direction. This accomplished, unless gangrene has set in, the normal colour returns to the intestines.

Untwisting is only half the operation. It is of fundamental importance to know that a second obstructive lesion—the transduodenal band of Ladd—is often present, and must be eliminated as has been described above.

MECONIUM ILEUS

Meconium ileus is the neonatal manifestation of fibrocystic disease of the pancreas, which more commonly presents in childhood with symptoms of steatorrhœa and recurrent respiratory illness. M. Bodian calls the abnormality *mucosis*, and it is hereditary. Mucosis affects many of the secreting glands of the body, notably those of the pancreas, the bronchial mucus-secreting glands, and the glands of the intestine—all of which, in this disease, secrete particularly viscid mucus. In meconium ileus the terminal ileum becomes filled with meconium admixed with this viscid mucus, and during the latter months of fœtal life

this becomes progressively inspissated. Often the contents of the lower ileum become putty like and the obstruction is complete. As in all cases of complete obstruction of the small intestine the colon is contracted and worm-like (microcolon) but in this instance the cæcum and ascending colon as well as the last few inches of the ileum, contain dry meconium pellets. The contents of the mid ileum are much more fluid. The inspissated meconium is so sticky that, given the opportunity it will adhere to the surgeon's gloves, the instruments, the towels protecting the skin edges, and the abdominal packs.

Diagnosis.—Meconium ileus has to be differentiated from intestinal atresia or stenosis, and that comparatively rare form of Hirschsprung's disease that affects the whole of the large intestine If trouble is taken the pre-operative diagnosis can be fully established. At times the loop filled with inspissated meconium, can be felt as a rubbery mass. A *typical radiograph shows distended coils, some of which are mottled. Unlike ileal atresia,* there is no abrupt termination The viscid meconium plugging the terminal ileum prevents gas entering the colon.

The X ray film digestion test is pathognomonic Into a bowl of vomit is placed a piece of exposed X ray film and it is left there for half an hour If trypsin is present, the gelatin that constitutes the sensitised coat of the film will be digested off In cases of meconium ileus nothing happens except a little softening of the piece of film. What could be simpler?

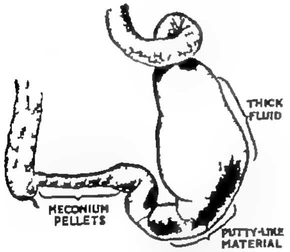

Fig. 647 —Operative findings in meconium ileus. (*After R. E. Gross.*)

Laparotomy —The presence of meconium ileus is confirmed if the operative findings resemble those depicted in *Fig* 647 (Cf. the findings in Hirschsprung's disease affecting the whole colon, p. 476) A freshly-made solution of 3 per cent hydrogen peroxide 1 part in water 3 parts should be available The loop containing the putty like material is isolated with abdominal packs and an incision about ½ in. (1 3 cm.) is made in its convex border Through this a fine rubber or gum-elastic catheter is inserted 3–4 in. (7 5–10 cm.) in a proximal direction, and 10 ml. of hydrogen peroxide is injected. After an interval of about a minute another 10 ml. is injected and after waiting a further minute the plug of meconium can be squeezed through the enterostomy using light pressure between the finger and thumb the plug is extruded easily Fluid meconium is then aspirated with a sucker Possibly a third injection of hydrogen peroxide is required A light clamp is placed across the intestine about 6 in. (15 cm) above the opening A catheter is passed distally into the intestine and the process of instillation of hydrogen peroxide is repeated. When the putty like material and a number of discrete meconium pellets have been extruded, the enterostomy is closed, followed by closure of the laparotomy incision.

The unique property of hydrogen peroxide in loosening the otherwise virtually inseparable plug of inspissated meconium was discovered by Ollm and Clutl. If another solution is substituted for hydrogen peroxide, the method is doomed to failure and efforts directed to clearing the lumen of the intestine result in trauma to its walls, as well as the waste of time from the necessity of repeatedly changing gloves soiled with this sterile but almost unbelievably sticky material Resection should be carried out only in the presence of threatening or actual gangrene Until recently resection of the loop containing the putty like material was considered to be the best treatment. If resection has to be undertaken, the operation is completed by constructing a double-barrelled enterostomy (see *Fig* 636, p. 471)

Post-operative Complications.—Even with full antibiotic therapy and placing the infant in an oxygen cradle the post-operative period is likely to be complicated with serious, if not fatal, collapse of the lungs or pneumonia. If the infant can be steered through the difficult period (over hydration is a constant danger) the child must receive medical treatment for years. After discharge from hospital the oral administration of one of the newer antibiotics often wards off recurring attacks of respiratory infection. These patients fail to thrive unless they are given pancreatin which prevents or mitigates the otherwise inevitable steatorrhoea.

MECONIUM PERITONITIS

Meconium peritonitis is not an uncommon cause of disease and death in the neonatal period 17 per cent of newborn babies with signs of intestinal obstruction suffer from meconium peritonitis, which can commence at any time during the last six months of foetal life. Meconium peritonitis is a sterile chemical peritonitis, and in a large percentage of cases the perforation becomes sealed during inter uterine life. If the perforation is still patent at the time of birth, to this chemical peritonitis is added bacterial peritonitis soon after the first feed.

Cause of Perforation: (*a*) In 50 per cent of cases the perforation is secondary to some form of congenital intestinal obstruction, the most common being congenital bands (p. 471) volvulus of the midgut (p 473) Hirschsprung's disease (p. 476), and meconium ileus (p. 473) (*b*) in 50 per cent of cases the perforation is idiopathic.

Site of Perforation.—The lower ileum is affected most often. Occasionally the perforation is situated in a Meckel's diverticulum exceptionally it is found in the stomach or duodenum. However in most cases, because it has become sealed during foetal life, the exact site of the perforation cannot be determined. Nevertheless, as a result of the chemical peritonitis, adhesions, often dense and widespread, are found, and occasionally these are the direct cause of intestinal obstruction

Fig 648.—Stenosis of the ileum with fluid levels, complicated by meconium peritonitis. Areas of calcification are present on the right side A safety-pin fastening the napkin is shown. (*I Swain.*)

Diagnosis.—In many respects the signs and symptoms of meconium peritonitis resemble those of intestinal obstruction in the new born. When a leaking perforation is present the abdomen is distended at birth early uniform abdominal distension is a more pronounced feature than vomiting When bacterial peritonitis has supervened, dusky oedema of the abdominal wall is often seen.

Radiography—In babies born with an open perforation the presence of gas within the abdomen, usually beneath the diaphragm, makes the diagnosis certain. In others, because extravasated meconium frequently calcifies, plaques of calcification (*Fig* 648) can sometimes be seen distributed through the peritoneal cavity even on occasions extending over the dome of the liver and exceptionally into the scrotum. It should be noted however that often calcification is too slight to cast an X ray shadow and that, when it is present, calcification giving a mottled appearance is more likely to prove to be intraluminar and associated with intestinal atresia or meconium ileus.

Pre-operative Preparation.—As abdominal distension may be so great as to severely embarrass respiration, and is liable to be a contributing cause of death, the administration of oxygen (in an oxygen-cradle if possible) is an early necessity but it is equally urgent to empty the stomach by aspiration Shock, dehydration, and electrolytic imbalance must be corrected.

Laparotomy.—Great care must be taken in incising the peritoneum, for the intestine is liable to be adherent to it. If gas and fluid escape, a search must be made for the perforation. In cases without intestinal obstruction suture of the perforation and drainage of the peritoneal cavity complete the operation. In at least one reported case the perforation had become sealed, and drainage of an infected loculus was all that was necessary.

In cases of perforation secondary to intestinal obstruction resection of the coil bearing the perforation, and completion of the operation in one of the two ways described on pp. 470, 471, is the only procedure likely to be followed by a successful issue. When, as is more usually the case, the perforation becomes sealed during inter-uterine life, in order to display the obstructing lesion the operator is often faced with a dissection of a tremendous number of dense adhesions. After the site of obstruction has been displayed, the particular lesion is dealt with in accordance with the instructions detailed in this chapter.

ALIMENTARY DUPLICATION

Alimentary duplication sometimes takes the form of a cyst lying in juxtaposition to a portion of the alimentary canal or, in the case of the small intestine, a length of jejunum or ileum is double-barrelled. Both types of abnormality can give rise to intestinal obstruction.

Duplication of the Duodenum.—The vestigial second duodenum is converted into a cyst lying in the concavity of the duodenum proper and the head of the pancreas. Excision must never be attempted. A window is cut in the cyst wall at a convenient place to make a large anastomosis between the mucus-lined cyst and the duodenum. When a large opening has been constructed between the cyst and the duodenum, the patient remains symptom-free.

Duplication of the Intestine.—Whether the duplication takes the form of a cyst or a long double-barrelled tube, the essence of good surgery is to excise the portion of the alimentary canal bearing the anomaly and to restore the continuity by direct anastomosis, or in the case of the lower ileum, by a Paul Mikulicz double barrelled enterostomy (*see* p. 471).

HIRSCHSPRUNG'S DISEASE

Usually the symptoms commence within 48 hours of birth. Vomiting, often bile stained, is followed by generalized abdominal distension, accompanied by waves of visible peristalsis. The passage of meconium is delayed, and often scanty. On rectal examination the rectum is empty; sometimes a ring of constriction can be felt by the finger-tip, and beyond this it may be possible to feel a fæcal accumulation. On occasions, as a result of a rectal examination or a barium enema, the obstruction is temporarily relieved, and in a few cases laxatives and enemata are sufficient to stave off the necessity for early operation.

Radiography.—A plain film shows distension of the large and the small intestine with fluid levels in most cases. The typical finding after a barium enema (the presence of a contracted segment with colonic ballooning above) is sometimes lacking in very early infancy; without this evidence there is always some uncertainty of the diagnosis.

Treatment.—Colonic lavage in Hirschsprung's disease is dangerous, for the wall of the aganglionic segment is weak, and is perforated easily. In most cases an operation to overcome the obstruction is necessary. In typical cases left lower laparotomy reveals a contracted rectosigmoid with immense dilatation of the rest of the colon. On two occasions at laparotomy Swain disimpacted fæces through the contracted segment, followed by the passage of a tube per anum; this relieved the obstruction successfully. Nevertheless the method cannot be recommended whole-heartedly, as there is no guarantee that intestinal obstruction will not recur.

Right transverse colostomy is often successful in relieving the obstruction, permitting the infant to become fit enough to withstand resection of the aganglionic segment by rectosigmoidectomy.

Atypical Cases.—The site of the cone of narrowing is frequently misleading. During fœtal life meconium can be propelled into a long aganglionic segment that extends into the right half of the colon. It is true that transverse colostomy is usually an effective method of relieving the obstruction in Hirschsprung's disease, but it fails utterly if the aganglionic segment extends into the right half of the colon. Should the aganglionic segment involve the whole colon, the distal ileum will be blocked with meconium, and taper in a cone-like manner towards the ileocæcal valve. These findings are almost identical with meconium ileus, *but the contents of the ileum in Hirschsprung's disease are entirely fluid*. What is best to do in a case of this kind is problematical. Ileostomy seems the only method likely to succeed.

IMPERFORATE ANUS

One infant in 4500 is born with an imperforate anus, or with imperfect fusion of the post-allantoic gut with the proctodæum. Within an hour of birth it is usually apparent that there is no anal orifice or that meconium is being discharged from an abnormal exit. Sometimes these obvious facts are overlooked for two or three days, by which time the infant is in the throes of intestinal obstruction.

Common Variety.—In over 80 per cent of cases the rectum ends blindly well up in the pelvic cavity 1 in. (2.5 cm.) or more above the anal dimple (*Fig.* 649). The first duty is to settle the important question as to whether the case before us belongs to this category or to one of the less common varieties that require different treatment. The perineum must be watched while the child cries; palpated and, if necessary, probed. In the male the external urinary meatus and the urine are examined for meconium. In the female the labia are separated with a view to finding an imperforate hymen bulging with dark meconium behind it, or a vaginal discharge of meconium. When no arresting information accrues from this careful examination of the region or, in the male, there is evidence of communication between the rectum and the urethra, if facilities exist the next step is:—

Fig. 649.—Imperforate anus. Common variety.

Fig. 650.—Radiograph showing the blind extremity of the gut in a case of imperforate anus. (*Wangensteen and Rice—by kind permission of "Annals of Surgery."*)

Radiography.—The infant should be radiographed in the inverted position with a metal button marking the anal dimple. In the inverted position gas accumulates in the blind extremity of the bowel, making it possible to visualize the distance between the hindgut and the proctodæum (*Fig.* 650). The absence of gas in the lower part of the colon is sometimes misleading in cases of imperforate anus, for in the presence of obstruction to its exit gas may not reach the rectum for 24 hours; therefore Rice's test is only reliable after that time. A lateral radiograph is particularly valuable for recognizing the rectum and sigmoid, because in an anteroposterior film a distended coil of ileum lying below the pelvic brim may be mistaken for the lower bowel.

Fig. 651.—Imperforate anus with recto-urethral fistula.

Fig. 652.—Imperforate anus. Simple septum.

Operative Treatment.—A left lower paramedian incision permits exposure of the blind distal end of the hindgut. In 50 per cent of males there is a communication with the prostatic urethra or the bladder, usually the former (*Fig.* 651). This fistula should be doubly ligated and divided, so that the renal tract suffers no more from infection from the bowel. Right transverse colostomy is then performed through a small transrectus incision. In cases where a communication with the urinary tract can be excluded, laparotomy is unnecessary; a blind transverse colostomy through a transrectus incision will relieve the obstruction. At the age of about 18 months an operation to construct an anal canal in the normal anatomical situation can be carried out.

A Simple Septum (*Fig.* 652) is a rarity. If the anal dimple bulges when the child cries, and particularly if the anal membrane is dark (meconium abutting against it), it is certain

that the case is one of a simple septum. To excise the septum and unite the edges of the mucous membrane to the skin gives a more perfect result than the cruciform incision that is commonly recommended.

Microscopical Anus (*Fig* 653) is so minute that only an occasional speck of meconium reveals its presence. Consequently it is frequently overlooked, and colostomy performed unnecessarily The only way of avoiding this mistake is to seek the minute opening with a probe. The sphincter mechanism in these cases is

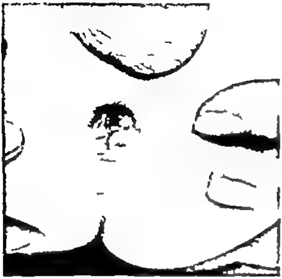

Fig. 653.—Microscopical anus. (*Denis Browne*)

Fig. 654 —Vaginal ectopic anus.

normal. Dilatation with bougies (Hegar's dilators are satisfactory) at frequent intervals effects a cure but bouginage must be continued at lengthening intervals for months, or years.

Stenosis of the Junction of the Hindgut with the Proctodeum is only discovered by rectal examination The treatment is regular dilatation with bougies.

Vaginal Ectopic Anus (congenital rectovaginal fistula) —The anus opens by a comparatively small hole into the vagina, whither stools are passed per vaginam. Usually the opening is into the lower third of the vagina (*Fig* 654) or near the fourchette It is only a matter of time and this small opening will become blocked, resulting in intestinal obstruction. Colostomy should never be performed for this condition.

Operation —An incision is made from the orifice, passing backwards beyond the anal dimple The incision must be kept open by packing until the raw surfaces epithelialize a process which takes place readily in this region. With packing and the regular passage of bougies, a functional, normal perineum results, unless the opening is high in the vagina when a plastic operation will be required when the patient reaches the age of about 6 years.

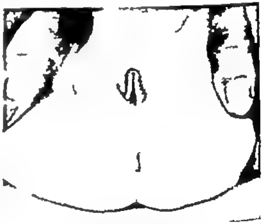

Fig 655.—Covered anus and vagina. (*Denis Browne.*)

Male Ectopic Anus is rare. There is a stenotic opening in the perineum near the base of the scrotum. The treatment is similar to the above.

Covered Female Anus (*Fig* 655) results from excessive fusion of the genital folds. A free incision backwards through the hood of skin will uncover a normal anus.

Covered Male Anus.—*Variety* 1 No anal orifice can be seen but a thin blue line can be discerned running forward from the anal dimple This is a sinus beneath the skin, oozing meconium. The treatment is to slit the sinus open and a normal anus will be displayed beneath the skin.

Variety 2 is combined with a hypospadias. Here again, the treatment is a free backward incision An operation for the rectification of the hypospadias will be required later

POST OPERATIVE TREATMENT APPLICABLE TO ALL CASES

Parenteral Fluid.—Once an intravenous cannula is in place, there is always the temptation to use a little more fluid than was decided upon. Often the little extra is the cause of death by drowning. 80 ml. per lb. per 24 hours should rarely be exceeded as a maintenance dose. It should be divided into two or preferably three administrations. To keep babies on the dry side during the early post-operative period is much better than combating œdema of the lungs and brain (R. E. Gross)

Sedation.—Small doses of phenobarbitone 2–6 mg. given by mouth or subcutaneously are often beneficial.

Respiratory Complications are liable to occur so quickly that it is essential to provide constant nursing care. A suction apparatus should always be at hand. After an operation of some considerable magnitude it is advisable to keep an infant's laryngoscope and suitable endotracheal tubes at hand; failing that, a tracheostomy set.

Antibiotic Therapy.—Penicillin 50 000 units 6-hourly and streptomycin 50 mg. twice daily are given intramuscularly almost as a routine post-operatively. Later in the post-operative period terramycin or aureomycin by mouth can be substituted. One complication of antibiotic therapy to which infants are prone is the development of thrush. The more usual antibiotics all enhance the growth of monilia. Should thrush appear the administration of antibiotics must be discontinued. If there is bacterial infection still to be combated, sulphathiazole ½ gr. per lb. (16 mg.) per 24 hours has a wide range of antibacterial activity.

Laboratory Assistance to assess the ever-changing state of alkalosis, acidosis, ketosis, and hæmoglobin levels is highly desirable.

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are accompanied by flatus and the passage of fæcal matter. In about 90 per cent of cases the reduction is complete. The passage of fæces and flatus, decrease in the abdominal distension, and the absence of a palpable lump are signs which point to success. If there

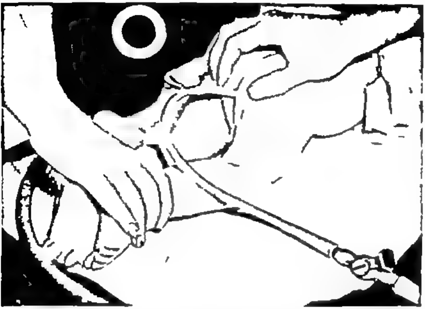

Fig 657.—Reducing an intussusception by means of hydrostatic pressure. The child was rolled over for purposes of photography in order to emphasize how the buttocks are pinched together. Inset is the exact size of the rectal tube used in this case of an infant aged 5 months.

Fig 658.—Doubt existed as to whether the intussusception was reduced completely in the case of the infant shown in *Fig* 657. A gridiron incision was made. It was found that the intussusception was reduced, and this is a colour photograph of the appendix, which was removed, showing hæmorrhages into it.

is the *slightest* doubt that the intussusception has not been reduced completely, laparotomy must be performed (*Fig* 658). Even so, time has not been wasted, for all that is necessary is a gridiron incision which can be made and closed quickly. This allows the crucial segment of the intestine, the ileocæcal junction, to be inspected thoroughly.

Fig 659.—When, under anæsthesia, the intussusception can be palpated in any of the positions indicated, right low laparotomy should be performed and the incision must be long enough to allow unhampered access to the lump. If the intussusception lies in the right iliac fossa, a gridiron incision is sufficient.

LAPAROTOMY FOR INTUSSUSCEPTION

The abdomen is opened by a right paramedian incision, one third being above and two-thirds below the umbilicus (*Fig* 659). Towels (abdominal packs soaked in saline do very well—the Turkish towels used for adults are too large) are clipped to the skin edges. The peritoneum is opened. The fingers seek for the lump in the left iliac fossa. If it is not there they pass in order to the splenic flexure, across to the hepatic, and down the ascending colon. The lump is usually found without difficulty. In most cases it is possible to deliver the mass which constitutes the intussusception through the wound into a warm, saline-soaked Turkish towel. Delivery is always possible when the intussusception is in the right half of the colon.

We will assume that, on opening the abdomen, the intussusception has been found in the left iliac fossa. It cannot be delivered by gentle manipulation, so we commence reduction intra-abdominally. The lowest part of the sausage-like mass is squeezed between finger and thumb (*Fig* 660); it will be found to move upwards: reduction has commenced. The manipulation is repeated again and again; each time some reduction is effected. When the mass has passed the splenic flexure usually it can be delivered on to the surface easily. With the intussusception wrapped in a warm, moist, abdominal pack, reduction by squeezing is continued outside the abdomen, where unhampered by working in a confined space the manipulation can

be carried out more easily. The last part of the intussusception is the most difficult to reduce and is best carried out in the manner shown in *Fig.* 601 but in the majority of instances complete reduction is soon accomplished. Indeed, the whole process from start to finish can be carried out in about thirty seconds. It will be noticed that after reduction the cæcum and last coil of intestine (if the intussusception be one of the ileocolic

Fig. 600.—Reduction of an intussusception. Always exert pressure towards the contracted entering layer. First manœuvre.

variety) are œdematous and injected. The appendix may look discoloured but, unless it is mahogany-coloured or black, it should be left alone. "Any of the devices to shorten the mesentery or anchor the cæcum are examples of misdirected surgical zeal" (Clubbe). The intestine is replaced and the abdomen closed in layers with tension sutures under the anterior sheath of the rectus abdominis. When the time comes for these to be tied, remember not to tie them too tightly for a baby's tender skin is traumatized easily and this is a potent source

Fig. 601.—Reduction of an intussusception. Second manœuvre.

of an unhealthy wound. The dressing of the abdominal wound requires care. If you try to keep the dressing in place by a many tailed bandage in a very short time you will find the dressing on the child's back instead of its abdomen (Clubbe). After the gauze has been applied a flexible adhesive plaster dressing is all that is required.

After-treatment.—The child is returned to bed and anti-shock treatment continued. The foot of the bed is raised and blood, plasma or dextrose-saline solution is given intravenously in accordance with the patient's needs. Subcutaneous dextrose-saline solution

with hyaluronidase may suffice. In an average case an intravenous drip is for 24 hours after operation Nepenthe, min. 1 (0·06 ml.) is given by mouth e hours for the first nine hours. It is important to keep the gastric aspiration tub and to continue to aspirate. Among other benefits, this will prevent aspiration shortly after operation. As long as coloured fluid is recovered aspiration should Only sufficient sips of water to keep the mouth and œsophagus moist are p these small amounts being, of course, aspirated promptly After reversed peri ceased the gastric tube can be withdrawn, and oral feeding commenced cauti the child is breast fed and he will suck, breast feeding is started the mother bendin prone child, for two minutes on the first occasion, four minutes on the second later after which proper feeding can be started. If the child is not breast fed, di and albumen water is substituted. No purgatives are to be allowed under any con If the bowels have not acted by the end of the second day a gentle rectal wash-o and repeated as necessary

Stage of Reaction.—About the forty-eighth hour there is often a rise in te perhaps to 102° or 103° F (38·9 –39·4 C.). This is not of grave significance, and t usually abates about the fourth day If the temperature reaches 105 F (40·5 usually a harbinger of a fatal prognosis. Pyrexia is due to the assimilation of of necrosis liberated from the damaged intestine.

Removal of Stitches.—The stitches should not be removed before the tenth the abdomen was difficult to close the stitches should be left in until the twelft is a good practice to put on a little pair of corsets before the stitches are Burst abdomen was formerly a common complication of intussusception ca less frequent now that the danger is recognized and guarded against.

Other Post-operative Complications.—

1 *Diarrhœa* is not infrequent. While the diarrhœa lasts, appropriate fl be given by parenteral routes, and nepenthe min 1 (0·06 ml.) for each year of a by mouth six-hourly Antibiotic therapy should if possible be specific for the organism. Strict precautions must be taken to prevent the infection spreadin children in the ward.

2. *Post-operative peritonitis*: Routine antibiotic therapy has reduced the of this lethal complication. Cultures taken from the serosa of a reduced intus of 28 or more hours duration are usually positive—a fact that emphasizes the giving antibiotic therapy in every case.

3. *Recurrent idiopathic intussusception* although rare, is a condition to be mind even in the early post-operative period. Distension and the continued retaining the gastric aspiration tube for more than 48 hours are usually caused b to the peritoneal coat; should the question of recurrent intussusception arise enema is helpful in arriving at the correct diagnosis. The diagnosis is made easily when there is a longer interval and the patient has been discharged from The interval between the initial attack and the recurrence varies from thir upwards.

The treatment is to open or to re-open the abdomen. After reducing the int tion, unless the condition of the patient is poor it is advisable to anchor the the fascia of the right iliac fossa by several interrupted stitches.

THE INTUSSUSCEPTION IS IRREDUCIBLE BY THE METHODS ALREADY DESCRIBED

Irreducible intussusception is comparatively rare.

We will assume that the intussusception can be reduced so far but no far On no account, under any condition, must the entering layer be pulled—" push, but never pull" In order to lessen venous and lymphatic engorgemen attempt at reduction should be preceded by pressure exerted evenly over the wh preferably covered with a moist pack. This should last not more than ½ minut followed by :—

Sawyer's Manœuvre of reducing an otherwise Irreducible Intussusception.—T and forefinger are placed as shown in *Fig* 662, and gentle pressure is exerted—the is increased gradually in such a manner as to produce gradual relaxation of the valve. At first the valve is felt as a firm, almost cartilaginous ring, but if suffic

is taken it opens gradually and if reduction of the intussusception is again attempted it is likely to be successful. If the intussusception is still irreducible, gangrene of its innermost layers is imminent or has occurred and resection must be carried out.

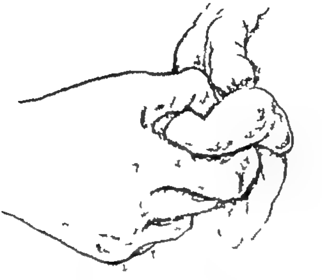

Fig. 662.—Sawyer's manœuvre for endeavouring to render an irreducible intussusception reducible.

INTUSSUSCEPTION PROTRUDING FROM THE ANUS

The differential diagnosis between prolapse of the rectum and intussusception may cause considerable confusion, for in both conditions there is a large rosette of inflamed mucosa presenting externally. The diagnosis should be simple if we really think about it. In rectal prolapse the projecting mucosa will be felt to be continuous with the peri-anal skin, whereas in intussusception the finger passes *ad infinitum* into the depths of the sulcus (*Fig.* 663). Nevertheless an intussusception protruding from the anus is frequently diagnosed as a rectal prolapse in the first instance.

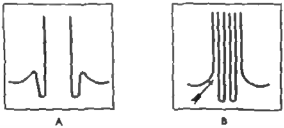

Fig. 663.—The differential diagnosis between prolapse of the rectum (A) and intussusception protruding from the anus (B).

A little girl, aged 4, was sent to hospital because of "rectal prolapse." The mother noticed a mass protruding from the anus which had bled since morning. The child looked pale and ill, and on further interrogation it transpired that she had had intermittent colic for twelve hours, and had vomited once. On examination, an intussusception was seen protruding quite three inches *from* the anal verge. Laparotomy. Ileocolic intussusception reduced. Recovery.

Male, aged 4½. Four hours before admission, whilst coughing, a large red mass protruded at the anus. There was no shock and no pain. The child appeared quite rosy and well. On *examination*, a mass of mucous membrane could be seen protruding from the anus. The finger, however, passed *ad infinitum* into the depths of a sulcus. Under an anæsthetic it was possible to palpate a mass in the left iliac fossa continuous with the anal protrusion. Laparotomy. Colo-colic intussusception reduced. It ended in the right half of the transverse colon. Recovery.

In both cases a particular feature was noted. The intussusception was readily reducible into the rectum, but it very soon reappeared through the sphincter. *The following*

plan was therefore adopted. The intussusception was reduced into the rectum and assistant kept it in place with his finger until the abdomen had been opened (*Fig.* 6 The apex having been grasped from within, reduction was carried out in the usual man

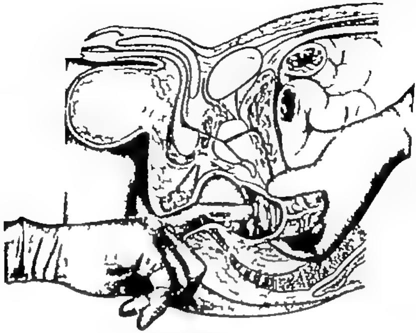

Fig 664.—In orde to rèduce an intussusception protruding from the anus t may be necessary to employ n unsterile assistant in the manner shown.

IRREDUCIBLE AND GANGRENOUS INTUSSUSCEPTION

Resection is required if reduction is not possible or if the bowel fails to regain its nor colour or peristaltic activity In the majority of cases resection will entail perform right colectomy The affected bowel having been mobilized and its mesentery divi it is exteriorized and the abdominal wall closed around the afferent and efferent limbs,

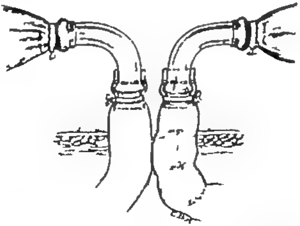

Fig 665.—Only after the abdominal wall has been closed around the spur created between the ileum and the colon is the diseased intestine excised.

which are neither sutured to one another nor attached to the abdominal wall. After protecting the closed laparotomy incision intestinal clamps are applied the devitalized bowel is excised and a Paul's tube is tied into each of the divided ends (*Fig* 665).

The second stage of the operation is performed approximately 48 hours later A stout ligature is tied around each limb of the bowel between the Paul s tube and the skin.

The bowel is then divided just distal to these ligatures, thus removing both Paul's tubes with a fringe of intestine around each. The stumps and surrounding skin are cleansed with cetrimide and the skin sutures are removed. The surgeon then re-scrubs, and having donned a fresh gown and gloves, proceeds as follows: the abdomen is re-opened; the two limbs are freed from the abdominal wall and from one another. The terminal inch (2.5 cm.) of each limb is œdematous, and does not hold sutures well. This short cuff on each end is excised. The continuity of the intestine is restored by closing each end with two layers of sutures, followed by side-to-side anastomosis. The two-stage resection, as described above, carried the lowest mortality in intussusception of infants. In cases of resection blood transfusion is very valuable and should be given as soon as matched blood is available. Both gastric aspiration and the intravenous drip are continued for at least three days. It is usually wise to extend the period to four days.

INTUSSUSCEPTION OF THE APPENDIX

Although it is encountered occasionally in youth or in early adult life, intussusception of the appendix usually occurs in infancy or early childhood. When the intussusception can be reduced, appendicectomy can be performed in the usual manner. More often the intussusception is of some standing, and œdema and inflammation render reduction

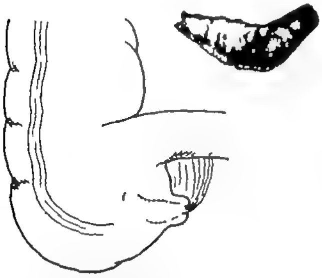

Fig. 666.—Intussusception of the appendix. Inset shows the intussuscepted appendix removed. (*A. Evans, British Journal of Surgery.*)

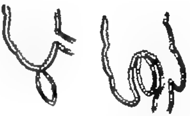

Fig. 667.—Intussusception of a mucocele of the appendix. (*After Isabella Forshall.*)

impossible, in which case the meso-appendix is divided and ligated. An intestinal clamp is then placed across the caput cæci and the area isolated by abdominal packs. A short incision is made into the cæcal wall, ending at the site of inversion. There is now no difficulty in removing the intussuscepted appendix (*Fig.* 666) and closing the small opening in the cæcum. A mucocele of the appendix sometimes intussuscepts (*Fig.* 667).

ACUTE INTUSSUSCEPTION IN ADOLESCENCE

The cause of intussusception in adolescent life is so regularly an inverted Meckel's diverticulum that a precise pre-operative diagnosis can often be made.

ACUTE INTUSSUSCEPTION IN ADULTS

Idiopathic intussusception, so common in infants, is a surgical curiosity in the adult. A. W. Mooro recorded two cases which occurred in Cairo during the Mohammedan fasting season. Presumably the abnormal peristalsis caused by the pangs of hunger determined the invagination. H. G. Nichols is one of the few surgeons practising in Europe or America to have encountered a case of this kind. Idiopathic intussusception of the cæcum is less rare. His patient was a white male, aged 28, and the intussusception was an ileocolic one, which was reduced successfully.

Nearly *all acute intussusceptions* occurring in adult life are initiated by some tangible pathological lesion when the intussusception is unravelled, an intestinal polypus, a submucosal lipoma, a somewhat pedunculated carcinoma an inverted vermiform appendix, or an inverted Meckel's diverticulum will be found.

Intussusception has also followed an abdominal injury probably a submucosal hæmatoma is the initiating lesion in such cases. In extremely rare instances a foreign body for instance a metal screw (Burke and Williams), has been found at the apex of the intussusception.

Fig 668 —Ileo-ileal intussusception caused by submucosal lipoma.

Less obvious, but certainly not idiopathic is when *an intussusception complicates an inflammatory lesion* of the bowel, as in E. Parry s case a non-commissioned officer of the Indian Army developed ileocolic intussusception while suffering from amœbic dysentery

The early symptoms and signs of acute intussusception in adolescent and adult life do not differ from those so well known in the case of infants. However because the condition is rarer it is seldom diagnosed until the intussusception is irreducible or even *gangrenous*.

Mrs. S., aged 47 was admitted as a case of subacute intestinal obstruction. She gave a history extending over ten days of intermittent abdominal pain, accompanied by occasional vomiting. Abdominal examination revealed nothing definite although there was a slight *suggestive fullness*. As an *enema yielded a fair result, she was kept under observation*. Two days later she had had an attack of violent abdominal pain and had passed a quantity of blood per rectum. A rather hard, tender lump could be felt in the hypogastrium. The rectum was empty but the examining finger was covered with blood Laparotomy A large ileo-ileal intussusception was delivered. Reduction was commenced, but soon a point was reached where it would reduce no further The intussusception was wrapped in a hot towel and reduction was again attempted. Something was felt to give On opening the towel it was seen that the external coat had split along its whole length, revealing the steaming purple-black intussusceptum within Intestinal clamps were applied and resection was performed. The distal end of the remaining small intestine was found to be within an inch or two (2 5–5 cm.) of the ileocæcal valve. The ends of the small intestine were closed and lateral ileocæcostomy was performed Recovery Five years later the patient was in perfect health.

The specimen is shown in *Fig* 668 The intussusception was caused by a submucosal lipoma.

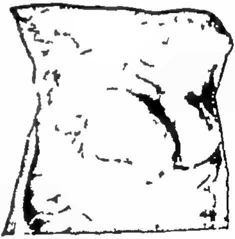

Fig. 669 —Interior of the intussusception excised from Mrs. R. Histological report fibromyoma

Mrs. R., aged 50, had a long history of attacks of acute abdominal pain which had defied diagnosis. Eighteen months previously upper laparotomy had been performed, and the patient stated she thought that a gall-stone had been removed. On palpating the abdomen a lump was felt below the umbilicus. *For forty-eight hours the patient had been vomiting*, and her general condition was poor After resuscitative measures, right lower laparotomy was performed. On opening the abdomen a large intussusception of the ileum was delivered. This was reduced with difficulty and after reduction the peritoneal and muscle coat were found to be split in a number of places. Resection of the damaged intestine was therefore undertaken 4 ft (1·2 m.) being removed. End-to-end anastomosis was used to restore the continuity of the gut, and the suture line was reinforced with a free omental graft. The patient stood the operation well. On examining the specimen the cause of the intussusception was shown to be submucosal growth (*Fig* 669), which on histological examination, proved to be a fibromyoma.

Forty-eight hours after the operation her condition became grave. The pulse rose to 136, due it was considered, to delayed shock. A rapid plasma infusion was therefore given with great benefit and continued by the drip method for 24 hours. Thereafter the patient recovery was straightforward.

Adult colo-colic intussusception usually produces only partial obstruction, and permits thorough pre-operative preparation of the patient for 24 hours. The prognosis of carcinoma in these cases is particularly good because intussusception implies a comparatively early growth and a long uninfiltrated mesentery at the time of diagnosis.

SPONTANEOUS SIGMOIDO-RECTAL INTUSSUSCEPTION

This is a variety of intussusception of adults which must be considered separately because usually the symptoms are totally different from those we are accustomed to associate with intussusception. In many of the cases pain is singularly absent until inflammation or gangrene sets in. Shock is singularly absent even after considerable intussusception of the sigmoid into the rectum.

For purposes of recognition and management, the cases can be divided conveniently into two varieties: (*a*) Those occurring in old people where a patulous anus permits the intussusception to protrude without hindrance. (*b*) Those not so old where little or no rectal protrusion occurs.

Type A.—The patient is almost always over 70 years of age; there is a large mass of congested mucous membrane protruding from the anus (*Fig.* 970). It is often 5–6 in. (12.5–15 cm.) in length, and may be more. Even a surgeon who has not encountered the condition before can hardly mistake the mass for prolapsed hæmorrhoids. In cases of some standing unsuccessful attempts by the patient to effect reduction increase the inflammation and œdema, and cause the coats of the intussusception to become stuck together with lymph.

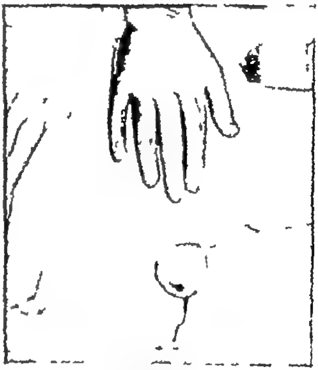

Fig. 970.—Sigmoido-rectal intussusception (Type A).

Treatment should be carried out in the operating theatre.

Technique of Reduction.—Take a towel wrung out in warm water and place it suitably so that the prolapsed mass can be steadily and firmly squeezed to drive out the œdema. Continue the pressure for some time. Gentle kneading is next employed to loosen the coats. The towel is then discarded, and employing small swabs to prevent the finger slipping, an attempt is made to reduce the apex in the same way as a paraphimosis is reduced (*see Fig.* 944).

M. G. was a thin wiry female of 88. Two hours before admission, whilst straining at stool, she noticed a lump appear at the anus. This got larger and larger, but there was no pain. When examined there was a mass of prolapsed mucosa the size of a baby's head protruding from the anus. There was no shock. Under gas and oxygen anæsthesia, little by little the mass was returned. Once the first part of the mucosa had been reduced, the remainder followed with comparative ease. After reduction had been effected the buttocks were strapped together with adhesive plaster. Recovery.

IRREDUCIBLE AND RECURRENT CASES

The following ingenious procedure is worthy of serious consideration. With the anæsthetized patient in Trendelenburg's position, a firm rubber tube approximately 1 in. (2.5 cm.) in diameter is passed up the lumen of the prolapsed sigmoid to a point 2–3 in. (5–7.5 cm.) above the level of the skin of the anus. A tight rubber band is then slipped up over the intussusceptum as high as can be reached conveniently, making sure that this point is not above the extremity of the rubber tube. The redundant mucosa is allowed to slough. In H. Bayard's case treated in this manner the slough separated on the ninth day;

O. H. Wangensteen's case took fifteen days. In both the end results were reported to be satisfactory and there was no stricture. Full antibiotic therapy is given during this treatment.

Type II is more elusive, for the protrusion from the anus is small or lacking. It occurs in younger patients, and the penalties of failure to recognize it include gangrene.

A dental surgeon, aged 54, sought advice after he had finished attending to his patients. In broken English (he was an Austrian) he explained that on account of a bloody discharge from the anus it had been necessary for him to wear a diaper for two days. Three days previously, after a large action of the bowels, he went to bed at 10 p.m. and at 12 midnight he was awakened with a feeling of again wanting to go to stool. This continued at 30-minute intervals during the night, and towards morning he noticed a discharge of blood and mucus, and felt some mucous membrane protruding from his anus. The following day he was better, but about 24 hours before his consultation the symptoms returned, and he had had an attack of abdominal pain lasting for 20 minutes.

Fig. 671.—Mikulicz's clamp in position after the 2 ft. (60 cm.) of exteriorized large intestine had been resected.

On examination, about one inch of congested mucous membrane was protruding from the anus. Rectal examination left no doubt that an intussusception was present. Within three hours he was anesthetized, and the abdomen was opened by a left paramedian incision. It was impossible to grasp the apex of the intussusception until the anesthetist (working beneath the towels which covered the patient's legs) had pushed up the intussusception with his gloved forefinger. Once a grasp of the intrarectal mass had been obtained, reduction of the intussusception presented no difficulty. No less than 2 ft. (60 cm.) of voluminous pelvic colon, bespattered with subserosal hemorrhages of varying size, were delivered. About 2 in. (5 cm.) of what had been the apex of the intussusception showed signs of impending gangrene. Paul-Mikulicz's operation was performed. One week later the exteriorized loop was resected and a Mikulicz clamp applied (*Fig.* 671). Thenceforth progress was uneventful.

Fig. 672.—G. H., 7 days after the second operation.

G. H., aged 63, passed blood per rectum and experienced some abdominal pain. His doctor examined him per rectum, and felt a mass which he thought was a neoplasm. Two days later the patient became worse, and on re-examination the doctor diagnosed an intussusception. A few hours later I examined the patient in hospital. On admission the abdomen was somewhat distended. There was a tender mass in the left iliac fossa, together with rigidity of the lower abdomen. The patient was in fair condition. On rectal examination it was discovered that the mass which had been felt by the doctor had disappeared. On opening the abdomen by a left paramedian incision, some gas and evil-smelling purulent fluid escaped. It was at once apparent that the pelvic colon was completely gangrenous. For the most part it was jet black, and here and there were areas of a green hue. Coils of small intestine were packed away from the gangrenous mass; the intussusception, on becoming gangrenous, had evidently reduced itself. As the condition of the patient was grave, as quickly as possible the gut was divided between clamps above the commencement of the gangrenous area, and its mesentery was divided and ligated. Complete gangrene of the gut was found to extend to the pelvic diaphragm. Consequently the whole of the pelvic colon and rectum were excised. The proximal end of the divided

colon was brought out of the upper part of the wound and a large drainage tube was inserted through the anus and another drainage tube through the lower end of the incision. The incision was closed as rapidly as possible, a Paul's tube being tied into the proximal end of the viable gut. Two pints of plasma were infused during the operation. Antibiotic therapy was commenced on his return to the ward. Surprisingly the patient rallied well. Four days later his general condition was remarkably good, but during that day the Paul's tube came out and the colostomy fell back into the depths of the wound. Transverse colostomy was therefore performed. *Fig.* 672 shows the patient seven days after the second operation. His subsequent progress was uneventful.

CONDITIONS WHICH ARE SOMETIMES MISTAKEN FOR ACUTE INTUSSUSCEPTION

PURPURA WITH INTESTINAL SYMPTOMS

A boy of 8 was admitted in a very collapsed condition, with a diagnosis of intussusception. He presented a typical picture of advanced upper-gut obstruction. The eyes were sunken, the tongue was dry and brown, the pulse poor. He had vomited almost ceaselessly for three days.

Fig. 673.—Subserosal extravasation of blood in purpura.

The note from his doctor stated that he had passed blood and mucus per rectum. On abdominal examination, there was an ill-defined lump immediately above the umbilicus. On turning the patient on to his side to make a rectal examination, it was noted that the buttocks were covered with purpuric patches, some of which were the size of a two-shilling piece. Purpuric patches were seen on the back and particularly on the lobules of the ears. A number of small spots on the extremities and the abdomen reminded one how easily these spots could be mistaken for flea-bites. The diagnosis of purpura was evident, but it was thought that there was a concomitant intussusception. The abdomen was opened, and a most astonishing picture was revealed. The jejunum for 4 ft. (1·2 m.) was the colour of bright-red blood, and on closer examination extravasated blood could be seen beneath the serosa (*Fig.* 673). The whole of this area was heavy with blood. No intussusception or obstruction was found, so the abdomen was closed. The patient was given parenteral fluid therapy and calcium lactate. Recovery.

Intussusception is a well recognized complication of purpura: a submucosal extravasation of blood probably starts the intussusception on its course. One should therefore always open the abdomen in suspected cases. Occasionally the supposed intussusception will prove to be a large subserosal hæmorrhage, as in the case related above.

Sir Hugh Lett recorded a case of intussusception complicating purpura where a second intussusception occurred four days after one had been reduced, evidently from a fresh patch of hæmorrhage. It follows that after an intussusception complicating purpura has been reduced, all in attendance should watch carefully for renewed symptoms. Timely re-opening of the abdomen may be indicated.

In a case of D. Fitzwilliams's, blood oozed from the wound continuously after operation, and the patient died. Timely blood transfusion will almost certainly avert this disaster.

ALARMING RECTAL HÆMORRHAGE IN UNSUSPECTED TYPHOID

A patient is seized with abdominal pain accompanied by considerable, if not alarming, bright red rectal hæmorrhage—thrice in my experience this syndrome has been the only manifestation of typhoid. In each instance the diagnosis of intussusception has been suggested by at least one clinician observing the particular case.

The amount of blood passed in cases of intussusception occurring during adult life is sometimes considerable; consequently the differential diagnosis becomes really difficult. In seven out of twelve consecutive examples of proved intussusception occurring in adolescent and adult life, a lump in the abdomen was felt at the clinical examination. In the seventh case sigmoidoscopy was rewarded by a unique view of the apex of an intussusception with a carcinoma upon it. Therefore in cases of copious bright red hæmorrhage when there is little or no mucus admixed with the blood and no lump to be felt within the abdomen or upon rectal examination, suspect typhoid.

A clerk, aged 30, was sent to hospital diagnosed as acute intestinal obstruction. The patient stated that five days previously he had been seized with acute abdominal pain, and soon afterwards had passed ½ pint (284 ml.) of bright-red blood. On the following day he had vomited twice, and again passed blood. The pain and the bleeding had continued and the stools were largely composed of blood. The patient did not look ill. His temperature was 99.6° F. (37.5 C.) and his pulse rate 96. On examining the abdomen it was at once evident that there was considerable distension. The rectum was empty and the examining finger disclosed a little blood upon it. An enema was given and was returned blood-stained without fæces. Sigmoidoscopy revealed some blood and blood-clot in the sigmoid, but otherwise the examination was negative. He was taken back to the ward and instructions were given to measure the girth of the abdomen every three hours, and also to report immediately any untoward symptoms. By the following morning the tape measure showed that the abdomen had enlarged more than 1 in. (2.5 cm.) and he complained of severe, spasmodic central abdominal pain. An enema produced the same result as before. A diagnosis of intussusception, probably due to an inverted Meckel's diverticulum, was made. On opening the abdomen, by a curious coincidence the first thing that presented was a Meckel's diverticulum over 2 ft. (61 cm.) in length. From its apex there was a cord running to the umbilicus. The cord and the diverticulum were excised, but as they were obviously not causing obstruction further examination was made. The cæcum and colon were examined systematically. On coming to the splenic flexure a change was seen and the whole of the large gut from this point onwards was thickened, blood-red, and hot. The abdomen was closed, and blood taken for a Widal reaction. The report was "Widal's reaction strongly positive." As the patient had never received any typhoid inoculations there was now no doubt that the symptoms were due to typhoid. Recovery followed.

INTUSSUSCEPTION THROUGH A COLOSTOMY

Usually following a gastro-intestinal upset, the mucous membrane prolapses through the artificial anus (*Fig.* 674). This is a common, and rarely serious, occurrence. The aid of gravity and gentle pressure with a warm, moist towel usually remedy matters. After reduction the opening should be strapped up for some hours, to allow œdema of the mucous membrane to subside, otherwise a return of the prolapse is likely to occur. Occasionally the protrusion assumes alarming dimensions; intussusception has occurred.

H. F., aged 74, was admitted with immense abdominal distension. In spite of enemata, his bowels had not been opened for ten days. The pulse was barely perceptible, his face pale and his extremities, especially his feet, were deeply cyanosed. Gastric aspiration produced a quantity of bile-stained fluid. Continuous intravenous dextrose-saline together with methedrine 30 mg. intramuscularly was administered, and his pulse improved perceptibly. He was taken to the operating theatre. With a view to performing blind transverse colostomy a short transverse incision was made in the right hypochondrium.

A loop of colon was delivered through the incision. It was of the dimensions of the inner tube of a motor tyre. It was noted that the loop was not of the transverse colon, as would be expected from the position of the incision; the great omentum was not attached to it. The apex of the loop was opened and a rubber tube sewn in. Much gas, but no fæcal matter escaped. After completing the colostomy the patient was returned to bed, with little hope of his recovery. For three days he remained in a more or less moribund state and although the distension had assumed less extravagant proportions, he was still distended and the colostomy had not acted. On the evening of the third day following irrigation through the colostomy the Sister-in-charge was rewarded by a copious fæcal result. From that time his condition steadily improved, and at the end of three weeks he was convalescent. A barium enema revealed ballooning of the pelvic colon, and barium issued from the colostomy opening. Uncertainty as to the nature of the obstruction, his advanced years, and his erstwhile moribund condition were the factors that led to a decision to send him home with a colostomy belt and the proviso that if all went well, his case was to come up for review in three months' time.

Fig. 674.—Prolapse through a cæcostomy. It was reduced easily and a few days later the cæcostomy (which had been performed for local gangrene associated with gangrenous appendicitis) was closed uneventfully.

Six weeks later his doctor was hastily summoned and found more than 1 ft. (30 cm.) of gut prolapsed through the colostomy. The patient was in good condition without pain or even discomfort. Issuing from the colostomy was a dusky sausage-like mass. Reduction of the mass was attempted in the patient's home. The intussusception was wrapped in a moist towel and squeezed for some moments in order to reduce the œdema. This appeared moderately successful. Reduction similar to that used in the orthodox method of reducing a paraphimosis was then attempted, also with partial success, but about 4 in. (10 cm.) still remained without. Up to this time the patient had experienced but little pain. A further effort was made with more force and my thumb passed right through the mucous membrane and entered the peritoneal cavity and some clear peritoneal fluid was liberated. Shortly after this some of the intussusception which had been reduced was extruded.

The patient was sent to hospital. Under general anæsthesia the colostomy opening (with the intussusception protruding therefrom) was freed from the abdominal wall, and 18 in. (45 cm.) of distal redundant colon and about 8 in. (20 cm.) of proximal colon were delivered. Before proceeding further it was ascertained by intra-abdominal palpation that there was no growth or other abnormality to account for the original obstruction. The two limbs of the colon were anastomosed by the Paul-Mikulicz procedure, and the intussusception, together with the redundant portion of colon, was excised. The total length of colon removed, which included the intussuscepted portion, was nearly 3 ft. (90 cm.). The patient made a good recovery.

When an intussusception through an artificial anus cannot be reduced easily in the early stages, it usually means that the opening in the skin has contracted, and the experience of the above case indicates that it is unwise to employ any force when the intussusception

base of the mesentery (J O Herrlin) A very fine hypodermic needle should be employed and care be taken not to prick a blood vessel.

The gut is viable Inspect the constriction marks (*Fig* 678) with keen vigilance, especially in cases of strangulated femoral hernia. The proximal constriction has borne the brunt of the obstruction; when the rest of the gut has resumed its pristine rosy hue, this band may remain pale. Sometimes, if the line is scrutinized, it will be found that it is composed of little more than the serosa. The surgeon will be well advised to invaginate this area on the least provocation with a well-soaked (pliable) length of intestinal catgut mounted on an eyeless needle the area is pleated taking care not to narrow the lumen unduly Alternatively interrupted cotton mattress sutures can be used.

The viability of the intestine is somewhat doubtful in circumscribed areas. Patching is indicated If the greater omentum can be found it is pulled down and the doubtful gut wrapped in it, sutures being placed to maintain the omentum in its desired position.

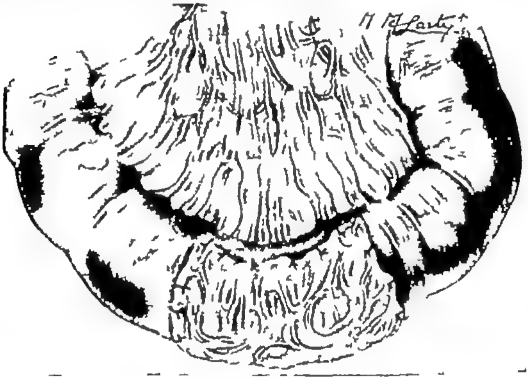

Fig 679 — A doubtfully viable circumscribed area patched with a piece of free omentum.

If there is the slightest tension on the omentum subsequent intestinal obstruction by band or kink is to be feared On this account the preference is for a free omental graft. A liberal piece of omentum is resected, and sutured accurately so as to form an overcoat for the whole of the affected loop (*Fig* 670). I have used this method many times, and never with regret If the omentum cannot be found and this is sometimes the case when it is wanted most, then recourse will have to be made to invagination or resection. The unavailability of omentum may be the determining factor in deciding for resection.

It has been shown experimentally that the free omental graft lives, except in the presence of gross infection. A thin omental graft remains practically unchanged for at least six months; a fat laden omentum is less likely to survive

A small (not more than half an inch in diameter) gangrenous area can be invaginated (see p. 492).

The gut is gangrenous the condition of the patient is fairly good Resection with anastomosis is indicated. It is unusual for any difficulty to arise on account of limited access to the peritoneal cavity afforded by an inguinal incision. Nearly always sufficient intestine and mesentery can be drawn down for resection and anastomosis to be carried out with comparative ease Should the surgeon be hampered for room, the fibres of the internal

oblique forming the internal abdominal ring can be incised in an upward and outward direction. In every case of gangrenous enterocele full precautions should be taken to prevent the supervention of gas gangrene (see p. 130).

The gut is gangrenous — the condition of the patient is grave. Exteriorization of the affected loop through a short abdominal incision (see p. 404) is the best that can be done under the circumstances. In this case no attempt should be made to repair the hernia. It is advisable to drain the peritoneal cavity via the hernial sac with a piece of corrugated rubber and to approximate loosely the muscle layers and skin about the rubber. When the condition of the patient brooches no delay the strangulated coil is left protruding from the inguinal incision. Both limbs of the intestine above the gangrenous area are lightly anchored to the skin.

In every case of exteriorization of gangrenous intestine in order to prevent massive absorption of toxins, it is highly desirable to excise the gangrenous portion and to tie Paul's tubes into the divided ends.

Methods of Dealing with some Rare Contents of the Sac.—

Twisted Ovary and Tube.—Attempt untwisting. If viable return the structures. If gangrenous remove them after carefully ligating the pedicle by transfixion.

Twisted Testis.—Attempt untwisting. Even when this is possible it will usually be found necessary to perform an orchidectomy because the cord is too short to place the organ in the scrotum. A maldescended testis should not be returned into the peritoneal cavity.

Inflamed or Gangrenous Appendix.—A strangulated or an inflamed vermiform appendix is not a very uncommon finding in a right inguinal or more usually femoral hernia operated upon for strangulation. Appendicectomy must be performed. If there is pus in the general peritoneal cavity suprapubic drainage should be instituted, after which the neck of the sac is closed and herniorrhaphy performed in the usual manner. It is, however, advisable to drain the subcutaneous tissues.

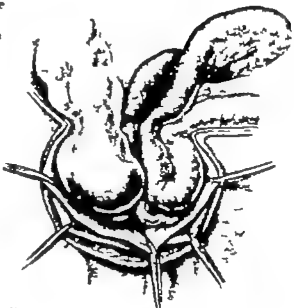

Fig. 690.—Retrograde strangulation of the intestine.

Mrs. W., aged 47, had a strangulated right femoral hernia. She was also suffering from a sore throat and raised temperature, circumstances which made local anæsthesia doubly desirable. When the hernial sac was opened, within was seen 1 in. (2.5 cm.) of the vermiform appendix, swollen and oedematous owing to its nipped condition. Although the obstruction at the neck of the sac was relieved, owing to fixity of the caecum it was found impossible to remove the appendix through the hernia incision. After infiltrating the abdominal wall over McBurney's point with local anæsthetic a gridiron incision was made and the inflamed appendix over 4 in. (10 cm.) in length was removed in the ordinary way. The hernial orifice was repaired by Lotheissen's method. The patient made a smooth recovery.

Pus (from Diffuse Peritonitis).—On clinical examination meteorism and a semi-reducible hernia are present. When the hernial sac has been opened it is found that its ballooning is due not to strangulation, but to an overflow of pus from the general peritoneal cavity. Place a drainage tube in the sac. If the patient's condition permits perform laparotomy. These patients are usually gravely ill, and it may be wise to limit the operation to suprapubic drainage.

Meckel's Diverticulum (The so-called Littré's hernia).—Crush the base of the diverticulum almost but not quite flush with its junction with the ileum. Cut off the portion distal to the crushing clamp with a cautery if one is available. Embed the stump with unabsorbable sutures. This procedure is referred to on p. 204.

A Diverticulum of the Bladder.—An eagle eye should be kept open for the possibility of a diverticulum of the bladder being in the hernial sac or in relation to the medial aspect thereof.

Retrograde Strangulation.—Attention is directed to this very rare and perplexing anomaly which appears to be more frequent in strangulated sliding herniæ. After relieving the obstruction, to one's astonishment the gut above the *point of strangulation* is found to be more unhealthy than the supposedly imprisoned loop below. The explanation is clarified by referring to *Fig.* 680.

In these circumstances, when the intestine is drawn down, unless *healthy* intestine soon appears, it may be wise to perform laparotomy through a lower paramedian incision in order to make certain that the obstruction has been relieved completely.

Maydl's Hernia, another rarity that can cause perplexity, is the imprisonment of two loops in the hernial sac, the loops being arranged just like a W. The middle segment of the W is usually long, and should both limbs of the W be gangrenous, the problem arises whether to perform a double resection, or resect a great length of the bowel. The latter course is usually in keeping with good judgment.

Reducing the Intestine from the Sac into the Abdomen.—Particularly in inguinal herniæ difficulty may be experienced in reducing intestine into the peritoneal cavity.

Aids to Reduction.—

1. Tilt the table slightly downwards by the head, so that gravity may aid reduction.
2. Put a retractor under the anterior lip of the peritoneal wound and retract upwards.
3. Reduce in orderly sequence, a little at a time, beginning at one end and gently squeezing the intestine between finger and thumb.
4. In extreme distension of the intestine evacuate the contents by means of a sucker, *having inserted, as a preliminary measure, a purse-string suture that afterwards is used to* close the puncture (*see* p. 419). In the absence of a mechanical sucker the contents of the distended coil can be evacuated into a dish through a fine cannula.

During all these manipulations it is of the first importance to keep as much of the intestine as possible under cover of warm, moist packs.

STRANGULATED INGUINAL HERNIA

Local Anæsthesia can be employed with satisfaction and great safety. The needle is inserted *about one inch (2.5 cm.) internal to the anterior superior iliac spine.* The superficial tissues are infiltrated over the inguinal canal and neck of the scrotum (*Fig.* 681). The incision (*see below*) is made, and the external oblique aponeurosis and the pillars of the ring are defined. The needle is inserted under the external oblique, and the injection is made upwards and outwards. With great care the medial aspect of the neck of the sac and the spermatic cord are infiltrated. In tense herniæ the last step can be deferred until the external oblique has been divided, when better mobilization and visualization of the parts to be injected can be made.

Fig. 681.—Area to be infiltrated with local anæsthetic in the case of strangulated inguinal hernia.

Operation.—Catheterization is an essential part of the preparation of the patient for operation.

The incision is made from the external abdominal ring outward and slightly upward. The less the scrotal area is *involved in* the incision the better, for sebaceous follicles which harbour myriads of organisms are extremely abundant in the skin of the scrotum. *Many* of the vessels in the subcutis can be caught and divided between ligatures before being cut. Towels are clipped to the wound edges. The incision is deepened until the aponeurosis *of the external* oblique is seen. Once the aponeurosis has been identified, the superficial structures can be stripped off it within the limits of the incision, and the anatomy of the region becomes clear. We see the tense sac

HERNIOTOMY FOR STRANGULATED INGUINAL HERNIA

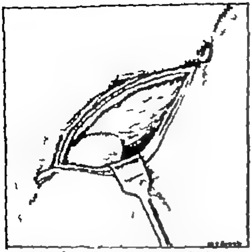

Fig. 682.—Strangulated inguinal hernia. The incision has been made and the superficial structures have been divided. The tense sac with its strangulated contents can be seen emerging through the external abdominal ring.

Fig. 683.—Strangulated inguinal hernia. Slitting up the sac from the fundus and dividing the constricting neck of the sac.

Fig. 684.—Dividing a tight constriction in the neck of the sac. The director protects the imprisoned gut.

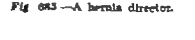

Fig. 685.—A hernia director.

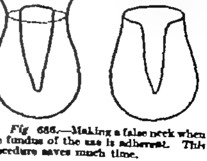

Fig. 686.—Making a false neck when the fundus of the sac is adherent. This procedure saves much time.

Three mattress sutures of non-absorbable material are passed in the following manner first through the external oblique then through the conjoint tendon over the cord through the inguinal ligament, again over the cord through the conjoint tendon, and out through the external oblique The free ends are clipped, but they are not tied for the time being Two or three of these sutures are inserted according to circumstances. The external oblique is sutured. Finally the mattress sutures are tied. The steps of the operation will be rendered clear by reference to *Fig* 687

IRREDUCIBLE OR STRANGULATED INGUINAL HERNIA IN INFANCY

The highest incidence of strangulated hernia in infants is between the third and sixth months.

In early cases commence treatment by giving a suitable dose of morphine placing the patient in high Trendelenburg's position, and applying a cold pack over the hernia for one hour Towards the end of this period, if spontaneous reduction has not occurred, taxis can be attempted

Contra-indications to Taxis.—(*a*) The lump is tender (*b*) The vomit is bile-stained or fæculent (*c*) There is redness or œdema of the skin over the hernial swelling

Method of performing Taxis (Denis Browne's technique).—Using the fingers of one hand to form a funnel leading to the external abdominal ring, the other hand grasps the lower end of the sac. By alternately squeezing and relaxing the fingers of each hand, a to-and fro movement of the contents of the sac, which are mainly fluid, is set up, and maintained until it can be felt to escape into the peritoneal cavity at first drop by drop of the fluid contents, and then suddenly the portion of entrapped intestine After reduction, operation should be performed as soon as convenient

Operation for Strangulated Inguinal Hernia in an Infant.—The operation does not differ in any essential respect from that described already

The point of obstruction in more than half the cases is at the external abdominal ring In the remainder a constriction in the sac itself is the obstructing agent There is no need to perform a plastic repair on the inguinal canal: removal of the sac is all that is necessary

A rather frequent finding in the course of the operation is death of the testicle. This is due to obstruction of the latter's very vulnerable blood-supply either by torsion or by compression of the artery at the external abdominal ring In the female a not uncommon content of the sac is the ovary apparently trying to follow the path of the male gonad

STRANGULATED SLIDING HERNIA

(*Hernie en glissade*)

Behind the posterior wall of the sac of a sliding hernia will be found (*a*) *on the right* side the cæcum and appendix (*b*) on the left side the pelvic colon. While intestinal obstruction may be due to strangulation of the extraperitoneal viscus more often it is due to nipping of a coil of small intestine within the sac proper (*Fig* 688).

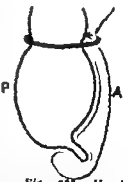

Fig 688.—*Hernie en glissade* The posterior wall of the sac is formed by the cæcum or the pelvic colon as the case may be P Posterior wall; A, Anterior wall.

Hernie en glissade presents no special feature as regards the relief of the obstruction, but perplexity may arise as to how to deal with the situation after the obstruction has been relieved A practical method is as follows the opening in the peritoneum is closed by a purse-string suture inserted as is depicted in *Fig* 689 When this purse-string suture has been tied, the long ends (by means of an aneurysm needle) are brought through the internal oblique (*Fig* 690). By rendering these long ends taut the whole mass can be reduced within the internal abdominal ring and after tying the free ends of the purse-string suture the neck of the sac is anchored behind the internal oblique This permits repair of the inguinal canal in the usual manner Particularly in elderly subjects the surgeon may feel justified in performing orchidectomy in order that the inguinal canal can be closed completely and thus reduce the incidence of recurrence of the hernia.

It might be argued that this is dangerous, and on a par with the deliberate performance of reduction *en masse* In practice the method answers admirably The

obstruction has been relieved, and the reduction of the extraperitoneal viscus permits repair of the inguinal canal.

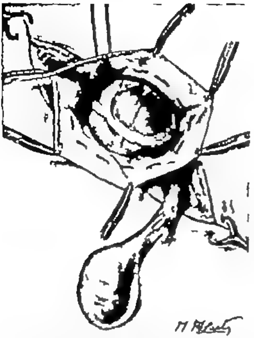

Fig 689 — Sliding hernia. Closing the mouth of the sac. Note that the purse-string suture is inserted near the blending of the gut with the peritoneum on the posterior wall. Consequently it encircles the free peritoneum of the sides and anterior wall at some distance from the open mouth of the sac.

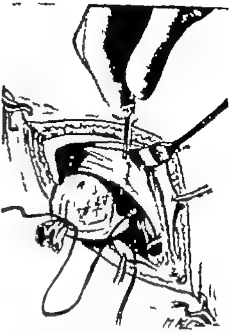

Fig 690.—Bringing the long free ends of the suture which closed the mouth of the sac through the internal oblique. Orchiectomy has been performed in order to close effectively the inguinal canal.

REDUCTION *EN MASSE*

In 60 per cent of the cases the condition is the result of taxis performed by the doctor In 35 per cent it is due to manipulations by the patient. In 5 per cent of cases the reduction is spontaneous. With a definite history of strangulation of a hernia, reduction by taxis, and a persistence of the symptoms of intestinal obstruction, the diagnosis of reduction *en masse* (*Fig* 691) is simple. When such a history is lacking the diagnosis becomes difficult: indeed, we can seldom get further than *acute intestinal obstruction*—? reduction *en masse* Two cases belonging to the latter category were seen in the space of a few months. In each instance the history was that the patient had worn a truss for years, but he denied there had been any recent complication in its management. On examination, an empty inguinal ring was noted and recorded, and as further examination revealed no other cause for the obstruction, the diagnosis of *acute intestinal obstruction*—? reduction *en masse* was made. Thus it came about that laparotomy was performed to confirm the diagnosis.

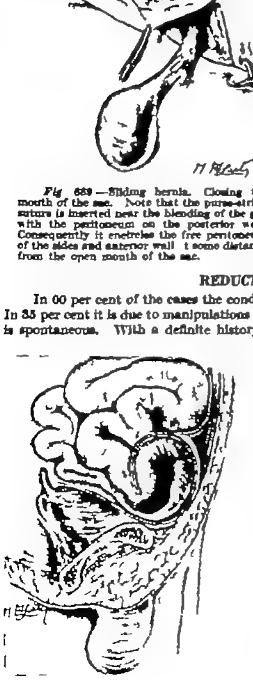

Fig 691 —Reduction *en masse*.

The notes of the operation on the first case are as follows :—

A right paramedian incision was made The small intestine was very ballooned. A collapsed loop was found, and traced to the right internal abdominal ring. In order to give better access to the region, the operating table was tilted so that the patient was in the

semi Trendelenburg position. After the intestine had been packed away the constriction was divided by a blunt-pointed bistoury on a director The imprisoned loop could now be withdrawn it was very congested. After treatment with warm moist packs, the gut appeared quite viable, and the loop was tucked away with the rest of the intestines under the towel. The internal abdominal ring was then sewn up with a purse-string suture (it was intended to repair the hernia and remove the sac by the inguinal route at a later date) The abdomen was closed.

The technique which was used in the operation upon the second case was almost identical.

In both these patients the abdomen became very distended and they died, one on the fifth and one on the sixth day after operation. Necropsy on the first case showed ileus only: but in the second case in addition a small quantity of blood-stained fluid was found in the peritoneal cavity this, on bacteriological examination was proved to be teeming with streptococci. Although in each instance the precaution of packing around the hernial orifice before division of the constricting agent was taken, there can be no doubt that the peritonitis was due to the entrance of infected fluid from the hernial sac

To obviate disaster the following method should be employed —

Lower laparotomy is performed and the diagnosis confirmed by verifying that a coil of intestine enters the internal abdominal ring The abdominal wound is covered with a towel, and the assistant is put in charge of the laparotomy wound. The surgeon makes a new incision over the inguinal canal, as for an inguinal hernia, and he retrieves the sac, if necessary aided by the assistant's hand within the abdomen (*Fig* 602) The surgeon deals with the strangulation as in an ordinary strangulated inguinal hernia. Finally the abdominal wound is sutured.

By employing this technique infected fluid within the hernial sac escapes externally An additional advantage of the method is that herniorrhaphy can be undertaken.

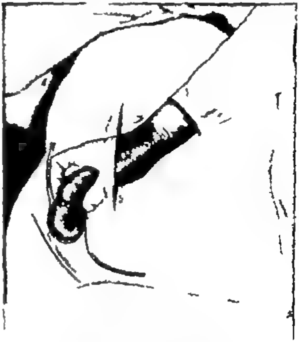

Fig 602.—Method of retrieving the sac in reduction *en masse*

This will be a convenient place to deal with those very rare conditions—strangulated obturator and sciatic herniæ. It will become apparent that from the point of view of operative treatment, they are comparable in many respects to a reduction *en masse*

STRANGULATED OBTURATOR HERNIA

About 500 cases of obturator hernia have been recorded ; most of these have been cases of strangulation. The condition usually occurs in elderly females In only 15 per cent of recorded cases was the patient a man. The patients are nearly always extremely thin, if not emaciated The symptoms are often obscure for frequently the strangulation is of the Richter type, and constipation is not absolute This fact accounts for late diagnosis and the relatively high mortality of the condition

In a fair percentage of cases, pain radiating to the knee (*Howship-Romberg's sign*) due to pressure on the obturator nerve in the obturator canal is present. If this sign is found in a patient with intestinal obstruction—or more frequently partial obstruction—for which no other cause can be found, it is possible to make a correct pre-operative diagnosis. A fullness (or even a lump) in Scarpa's triangle on one side is also a suggestive sign It is differentiated from a femoral hernia by the fact that the fingers can be pressed down on the pubic ramus above the lump without discomfort The limb is usually maintained in semiflexion and movements of the hip are limited by pain. Vaginal examination

sometimes clarifies the diagnosis, for a tender mass in the region of the obturator foramen (*Fig* 693) may be discovered In about 40 per cent of cases the obturator hernia has been recognized before operation.

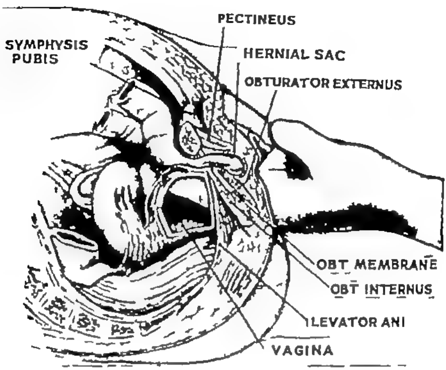

Fig 693.—Palpation of a strangulated obturator hernia via the vagina. (*After Sir Cecil Wakeley*)

Operation for Strangulated Obturator Hernia.—

Step 1.—*Lower Laparotomy* A coil of intestine is found passing to the obturator foramen where a portion of it is imprisoned. The operating table having been tilted into semi Trendelenburg position, the intestines are packed away so that the afferent and efferent limbs of the coil are displayed clearly The laparotomy wound is then covered with a towel.

Fig 694.—The relations of an obturator hernia. (*After Sir Cecil Wakeley*)

Step 2.—A vertical incision is made over the swelling on the inner side of the femoral vein The incision should be fairly long, and extend ½ in. (1 3 cm.) above the inguinal ligament. By dissection, the adductor longus is defined and retracted inwards (*Fig* 694). The fibres of the pectineus are retracted laterally or better divided transversely The obturator externus is defined the sac may appear above the obturator externus, or through its uppermost fibres. The sac is opened, and the fluid contents allowed to escape into a dry pack, which is discarded, after which another is placed beneath the sac

Step 3.—Returning to the abdominal incision often, by gentle traction, it is possible to withdraw the intestine from the obturator foramen Should this not be the case the constricting ring can be incised with a blunt pointed bistoury with due regard for the obturator vessels and nerve Having withdrawn the imprisoned intestine and

having attended to it according to its needs the hernial orifice must be obliterated whenever possible for if the sac is left, recurrence is almost inevitable

Step 4 — After reduction of the contents, E. F Soothill recommends that the fundus of the hernial sac be reached and disengaged from the obturator foramen by an extraperitoneal approach through the original laparotomy incision i.e. the peritoneum is stripped from the retroperitoneal tissues. Having withdrawn the hernia from the obturator foramen, the sac is excised. If this step is taken recurrence is most unlikely

STRANGULATED SCIATIC HERNIA

A. C. Perry recorded a successful case of strangulated sciatic hernia.

A married woman, eighteen weeks pregnant, was admitted with intestinal obstruction. She gave a history of recurrent abdominal pain and vomiting extending over seven days. At operation a collapsed coil of small intestine was traced to the right side of the pelvis. On attempting to bring it up, the intestine tore. Three inches (7 5 cm.) of ileum were resected, and end-to-end anastomosis was performed. The hernial sac was found to be situated in the right sciatic notch above the piriformis. The patient recovered and the pregnancy went to term.

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CHAPTER XLIV

STRANGULATED FEMORAL HERNIA

This emergency is most worthy of a separate chapter. It is very *common in every community*; it calls for a thorough understanding of the surgical anatomy of the region, and it is an operation that brings to the forefront those qualities which every operating surgeon wishes to possess—precision, neatness, and a mastery of the situation. There is no other common emergency operation that so frequently tends to get the beginner tied up. Should the patient happen to be a male, an added difficulty is the spermatic cord, which seems to be constantly in the way.

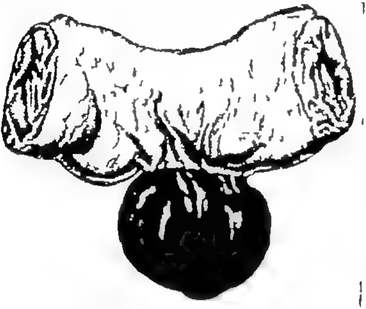


Fig 695.—Gangrenous Richter's hernia from a case of strangulated femoral hernia.

A point to be emphasized is the frequent occurrence of a *Richter's hernia* (*Fig* 695). When only a portion of the lumen of the gut is imprisoned the femoral *swelling is no* bigger than a cherry. In addition, the patient, not having *complete obstruction*, continues to have her bowels open or at any rate responds to enemata.

The small lump caused by a strangulated Richter's femoral hernia is liable to be overlooked *entirely* or *treated as* inguinal adenitis until the patient's condition has commenced to deteriorate.

In common with an ordinary femoral hernia, a strangulated femoral hernia is more common on the right side.

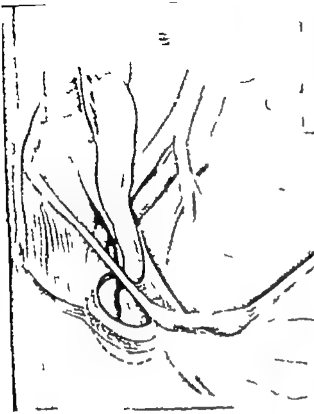
In 40 per cent of cases the contents of the hernia are gangrenous (J. C. Peden). Pre-operative signs of probable gangrene are (1) inflammation of the skin over the hernia, (2) fæcal vomiting and (3) a temperature over 100° F. (37·8° C.)

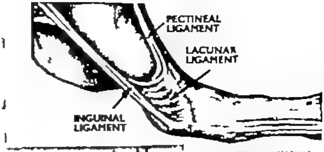
Taxis as a method of treatment for a strangulated femoral hernia is unjustifiable in a civilized country under modern conditions.

Fig 696.—Area to be infiltrated in the case of strangulated femoral hernia.

Local Anæsthesia can be confidently recommended, and is most effective for use in either of the operations for strangulated femoral hernia about to be described. The area of subcutaneous infiltration is shown in *Fig* 696. The *inguinal canal is anæsthetized in a manner* similar to that detailed in inguinal hernia. In addition the lower skin flap must be retracted and the parts about the sac itself infiltrated, care being taken not to pass the needle into the imprisoned gut.

SOME CLINICAL AND ANATOMICAL MEMORANDA





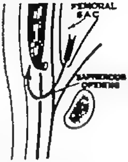


Fig 698 — A hernia passing down the femoral canal, at first descends vertically but on reaching the saphenous opening, joyous as it were at leaving such a narrow inelastic tunnel, it bulges through and enlarges, especially in an upward direction.

Fig. 697.—"The superior border of the pectineal crest is covered by a sort of fibrous cord, very thick, very resistant intimately adherent to the bone This is the pectineal (Astley Cooper's) ligament." (*Testut.*)

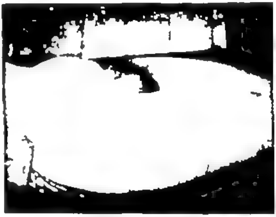


Fig 699 —A fully distended femoral hernia assumes the shape of a retort and its bulbous extremity often comes to overlie the inguinal (Poupart s) ligament.

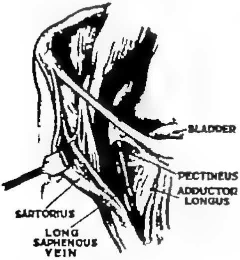


Fig. 700.—The femoral vein on the lateral side and the bladder on the medial side are the vulnerable structures that the surgeon should localize

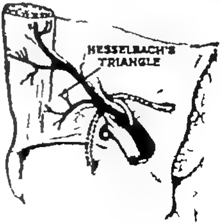


Fig 701 —The femoral canal and it immediate neighbourhood from within, showing the dangerous form of abnormal obturator artery If the lacunar ligament is freely divided the artery will be severed.

Occasionally a very small dose of intravenous pentothal may be given if the patient experiences pain. If pain is experienced during the operation, it usually means that infiltration around the medial aspect of the neck of the sac i.e., in the region of the lacunar ligament has not been carried out efficiently

OPERATION FOR STRANGULATED FEMORAL HERNIA

In the female The nurse who prepares the patient is instructed to pass a catheter and leave it in situ until the patient is on the operating table and there to empty the bladder using pressure above the pubes over the sterile towel.

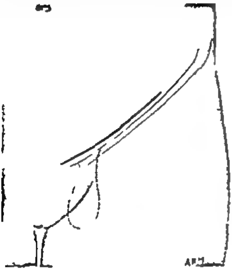


Fig 702.—The incision for femoral herniotomy Should more room be required the incision can be extended in the desired direction.

In the male a catheter is passed in the operating theatre.

By observing these rules, the very real danger of wounding the bladder is minimized.

Two operations, Hey Groves's and Lotheissen's, will be described. Of the two, Hey Groves's is the simpler The reader is particularly requested to note that the initial steps of both operations are exactly the same

The Incision is shown in *Fig* 702 It lies just above the inguinal ligament If necessary the medial end of the incision can be extended after suitably injecting more local anæsthetic Bleeding vessels having been ligated towels are clipped to the wound edges. The subcutaneous planes are then separated, and the external oblique aponeurosis is displayed.

In the male The following procedure that allows the spermatic cord to be displaced well away from the field of the operation is recommended. Infiltrate the spermatic cord with novocain solution, using a fine needle this anæsthetizes the testicle at once By pressure from below (the sterile towels intervening) deliver the testicle from the scrotum. By gauze dissection, separate the coverings of the testicle from the interior of the scrotum. As soon as the patient experiences discomfort infiltrate the gubernaculum. By further gauze dissection, a somewhat pedunculated attachment will be defined, which is divided between hæmostats (*Fig* 703).

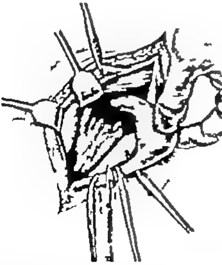


Fig 703.—Division of the gubernaculum.

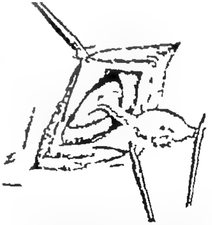


Fig 704.—The spermatic cord has now been mobilized, the testicle and the cord can be placed away from the field of operation.

Ligate the divided scrotal attachment securely Lift up the testicle and separate the cord to the external abdominal ring Split the fibres of the external oblique thus opening the inguinal canal, and continue the mobilization of the spermatic cord until the stage depicted in *Fig* 704 is reached.

Opening the Fundus of the Sac—The lower margin of the wound is retracted and the hernial sac enveloped in its coverings is evident. By gauze and forceps dissection its coverings are shelled off

Particularly in obese subjects, the thickness of the coverings of the sac may be surprising but once the peritoneal layer has been displayed, there is no mistaking it. Often discoloured contents can be discerned through the unopened semitransparent peritoneal sac. Attention is directed particularly to clearing the inner aspect of the sac, with a view to displaying the lacunar ligament. After this has been completed satisfactorily the fundus of the sac is laid upon a dry abdominal pack. The sac is incised and its contents are displayed. The principal object of this step is to allow the blood-stained fluid to drain into the gauze. This fluid is swarming with bacteria, and if it is not evacuated it is likely to run into the general peritoneal cavity at a later stage of the operation. Retractors are removed, and the sac, wrapped in a (new) moist pack becomes hidden by the lower skin margin.

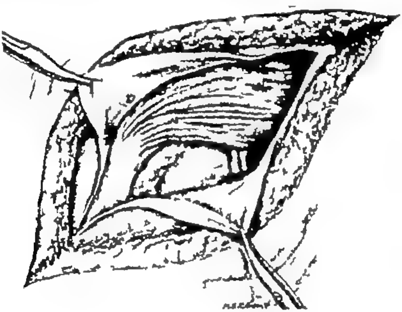


Fig. 705.—Identifying the conjoint tendon and opening up the space beneath it.

The Inguinal Stage of the Operation. Opening the General Peritoneal Cavity—The upper edge of the wound is retracted and the external oblique is incised from the external abdominal ring outwards, parallel to, and about ¾ in. (19 mm.) above the inguinal ligament. The inguinal canal is now open. The free edge of the internal oblique, as it sweeps round to mingle in the formation of the conjoint tendon is identified and made more obvious by blunt dissection (*Fig* 705). In a small number of cases the inferior epigastric vessels require division between ligatures. In most cases they need not be interfered with. The fascia transversalis is incised, or broken through with dissecting forceps, and the space beneath opened up with the fingers. The peritoneum is in view. It is well to be certain that it *is* the peritoneum and not the bladder. The peritoneum is opened with due care, and hæmostats are clipped to its free edge. The interior and the structures passing into the femoral hernia can now be inspected. If it is intestine the afferent and efferent limbs of the entrapped coil will be observed. The opening in the peritoneum is covered with a moist abdominal pack.

* *

Up to this stage Hey Groves's and Lotheissen's operations are similar

*

HEY GROVES'S OPERATION

There is no foundation for the prevalent conviction that the integrity of the inguinal ligament must be preserved at all costs. The end-results of Hey Groves's operation prove conclusively that the division of the ligament does not weaken the abdominal wall.

The internal oblique, as it joins the conjoint tendon, is retracted, and the peritone pushed up until the iliopectineal line is seen clearly Running along this bony margi reflection backwards of the lacunar ligament—the pectinate ligament (ligament of A Cooper). The forefinger of the left hand now seeks the beating external iliac artery as it p beneath the inguinal ligament. After the artery has been identified irrefutably the fore is shifted a finger s breadth to the inner side, and it here rests upon the bone. This fing the all important function of protecting the femoral vein, which cannot be defined by palp The finger is kept in place until all the deep sutures presently to be described, are p

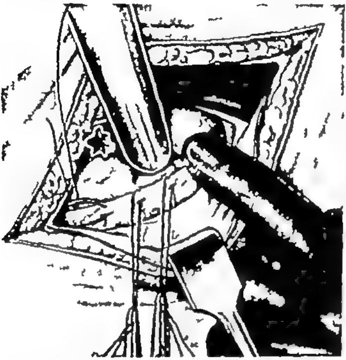


Fig. 709 —Radical cure of femoral hernia by Lotheissen's method Passing the deep sutures through the fascia overlying the iliopectineal line The left forefinger is protecting the femoral vein.

In order that the iliopec line may be clearly visible, go traction is necessary A val instrument for this purpo Sargent s retractor its s surface also helps to reflect into the depths of the wound is held by the assistant in s way as to keep back the int oblique and the peritoneum 709) With a small needle mo on a holder three occasionally interrupted sutures of linen t are passed through the perios and the pectinate ligament lying the iliopectineal line first of these is near the watching over the femoral vei the last near the insertion o lacunar ligament on to the After each suture has been p the needle is removed, and th free ends are clipped together hæmostat. A de-tempered, l able needle is very useful in pa these sutures, and it does not l if bone is encountered.

The remainder of the opera is easy to accomplish. All retractors are removed, and the guarding finger is taken a An empty curved needle is taken, and by its agency the free ends of the three su are passed from within outwards through the conjoint tendon. These are now tied, approximating the conjoint tendon to the iliopectineal line The edges of the ext oblique are sewn together and the skin edges are approximated.

SUPPURATING LYMPH NODE OF CLOQUET

There are occasions when it is impossible to make a differential diagnosi betwe strangulated femoral hernia (omentocele) and an enlarged deep lymph-node situated the femoral canal (*Figs.* 710 711). If an inflammatory enlargement is suspected, the genitalia, perineum, buttock, and anus are scrutinized for a primary focus. If this se is negative and the neighbouring lymph nodes are not enlarged the differential diag becomes impossible

In such circumstances it is better to operate at a convenient time within 24 t hours, or sooner when pain is present. Should an enlarged lymph-node or nodes be fo happily the surgeon has no cause for embarrassment the inflamed lymph nodes sh be removed by dissection. Often the principal node is found lying over the saphe opening and the saphenous vein may require ligation. I repeat that the surgeon sh not feel qualms at finding an enlarged lymph-node instead of a strangulated femoral he —particularly if he has stated beforehand that such a finding is probable

The details of three consecutive examples of this condition are as follows —

The patients were all stout women of about 50 years of age and none of them had any of a focus of infection, nor were neighbouring lymph-nodes enlarged. All patient stated the l

had appeared comparatively suddenly. In the first case, the patient was admitted as an emergency with a diagnosis of probable strangulated femoral omentocele; a solitary lymph-node the size of a large marble was dissected out. The wound was sutured, and it healed uneventfully. In the second case the patient presented a large hard mass beneath the inguinal ligament and her main complaint was pain on walking. She was taken into a nursing home, and as she had advanced mitral stenosis, expectant measures were adopted for a week. The lump was then explored under local anæsthesia, and it proved so hard and fixed that I thought that it was a malignant neoplasm. A piece was removed for microscopical examination; this was returned "inflammatory tissue." She was therefore anæsthetized and the whole mass was thoroughly exposed. Fully 1 in. (2·5 cm.) of œdematous fibrous tissue was traversed and it seemed probable that this might be coverings of a hernial sac. Eventually two enlarged lymph-nodes, each about the size of a chestnut, were encountered and enucleated with the finger. The thickened fibrous coverings were then excised. The wound was partially sutured and the cavity packed with petroleum-jelly gauze. Granulation proceeded apace and the patient was discharged with the wound healed in two and a half weeks.

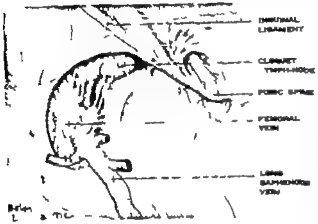


Fig. 710.—The relations of the saphenous opening.

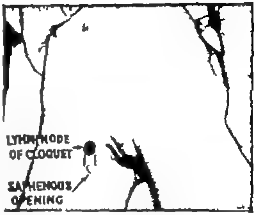


Fig. 711.—An enlarged lymph-node of Cloquet can simulate exactly a strangulated femoral omentocele or a strangulated Richter's hernia, or a strangulated femoral hernia containing some unusual structure, e.g., a diverticulum of the bladder.

The third case was seen in the out-patient department, and the diagnosis was discussed without arriving at a differentiation between the two conditions aforementioned. There was some delay in getting the patient into hospital, and when she arrived ten days later the skin over the swelling was reddened, and the lump had increased in dimensions. The fact that suppuration had occurred strengthened the probability of a suppurating lymph-node of Cloquet, but, of course, the contents of a femoral hernia may become gangrenous and give rise to the same phenomenon. In this instance the lesion proved to be the suppurating lymph-node, which was excised. The overlying unhealthy skin was excised, and the wound packed with petroleum-jelly gauze. The wound was re-packed at weekly intervals, and an excellent recovery ensued.

The following case typifies the possible dangers when an expectant attitude is followed in cases where the differentiation between an enlargement of the lymph-node of Cloquet and a strangulated femoral hernia is impossible.

A middle-aged woman developed a lump, which was diagnosed as saphenous adenitis of unknown origin. Suppuration followed, and the abscess was opened. The next day the patient's condition rapidly became grave; she failed to respond to restorative remedies. Necropsy revealed diffuse peritonitis and a femoral hernia containing a gangrenous perforated diverticulum of the bladder. (Werne and Garrow.)

A Thrombosed Saphena Varix is another condition that (much more rarely) simulates a small strangulated femoral omentocele.

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CHAPTER XLI

STRANGULATED UMBILICAL AND INCISIONAL HERNIÆ. EXOMPHALOS

Anæsthesia.—Local anæsthesia, after preliminary medication, is usually satisfactory. The area around the hernia is infiltrated as in *Fig* 712. The muscular layers of the abdominal wall are infiltrated in due course. Combined local anæsthesia and intravenous anæsthesia (thiopentone) answers admirably in these cases, the thiopentone being employed only if it is necessary. Inhalation anæsthesia is best avoided in cases of strangulated umbilical hernia, particularly because of the liability of these obese subjects to pulmonary complication.

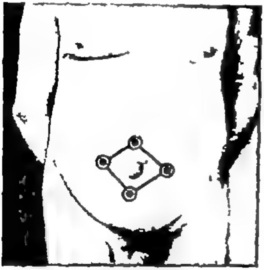


Fig. 712.—*Area to be infiltrated in the case of a strangulated umbilical hernia.*

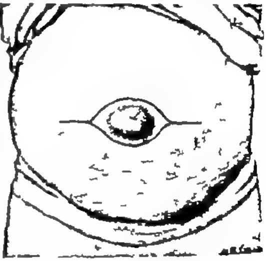


Fig. 713.—*Strangulated umbilical hernia. Incision for Mayo's operation.*

Operative Treatment : Preparation of the Skin.—On close examination, as often as not, a fold containing evil-smelling sebaceous material will be found. This must be cleansed with ether. When the skin overlying the hernia is eczematous, or otherwise infected, it can be encased by a layer or two of gauze soaked in collodion, or better still, by painting the whole of the operation area with Portex plastic skin applied half an hour before the operation. Attention to the skin is very important. If it is neglected, cellulitis of the abdominal wall, a grave complication, is likely to follow.

Fig 714.—Mayo's operation for strangulated umbilical hernia. Diagram showing the 'island' formed after isolation of the neck of the sac.

The Operation : Mayo's Method.—An elliptical incision is made encircling the hernia with a fairly liberal margin (*Fig* 713). The incision is deepened through the fat, at first above, then below, then to the left, and finally to the right. During the process the 'island' isolated by the incision is grasped in a towel and retracted at first in one direction and then in another. The object in view is to isolate the neck of the sac. When this has been carried out, the state of affairs is as represented in *Fig* 714. Retraction is then applied so as to put the neck on the stretch, and with a very gentle stroke of the scalpel, held obliquely, the neck is opened at one point. Once inside, the remaining portion of the circumference of the neck of the sac can be divided with scalpel or scissors (*Fig* 715), the finger acting as a guide to protect the underlying structures. We now have a large mass, comprising the sac together with the island of skin and fat, joined to the abdomen by the structures passing into the sac. This pedicle is scrutinized. If omentum is its sole constituent, it is ligatured and divided in sections, thus freeing the mass (*Fig* 716).

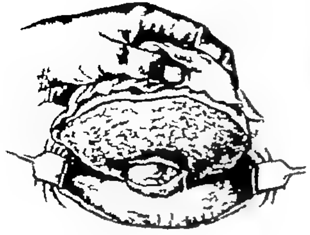


Fig 715.—Strangulated umbilical hernia. Opening the neck of the sac.

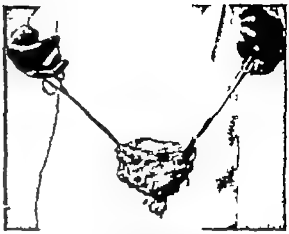


Fig 716.—Island of tissues excised during an operation for strangulated umbilical hernia

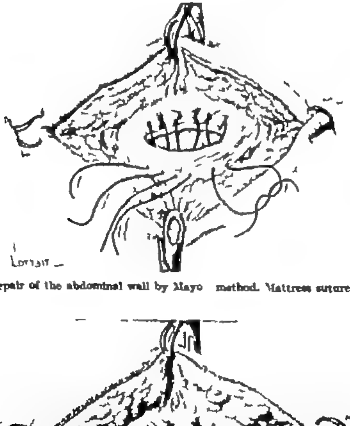


Fig 717.—Repair of the abdominal wall by Mayo method. Mattress sutures are passed.

Fig 718.—The mattress sutures are tied, and the resulting overlapping lower lip of fascia is fastened down by interrupted stitches.

If intestine is passing into the sac, the neck of the sac must be enlarged and the imprisoned gut delivered. It is then scrutinized and dealt with as its condition demands.

Repair of the Abdominal Wall.—The aponeurosis around *the upper lip of the wound* must be cleared of fat. The peritoneum inside the lower lip of the wound is roughened by rubbing it with gauze. Mattress sutures of unabsorbable material are now passed as shown in *Fig.* 717, and the roughened peritoneum of the lower lip comes to overlap the aponeurosis of the upper lip, to which on account of the roughening it is likely to adhere. The free edge of overlapping lip is now sutured to the aponeurosis (*Fig.* 718), and all that remains to be done is to close the skin incision. It is advisable always to put a drain in the wound for forty-eight hours, for there is a large dead space which is liable to become infected. By draining the subcutis and by the preliminary attention to the folds of the skin, cellulitis of the abdominal wall (a most fatal preventable complication) is avoided. I have laboured this point because, when acting as a house surgeon, I saw two patients die from this cause.

STRANGULATED INCISIONAL HERNIA

The midline lower abdominal incision is by far the most potent cause of this very serious condition. Strangulation of other incisional herniæ is comparatively rare.

Incarceration of an incisional hernia is a very dangerous and inaccurate diagnosis. The sac almost always contains small intestine, and—probably because the intestine has been entangled in adhesions for a considerable time—the symptoms of acute obstruction are to some extent masked. These patients appear to tolerate intestinal obstruction in a remarkable manner, whilst gangrene proceeds apace in the sac.

Fig. 719.—Strangulated incisional hernia. *Type* 1. For purposes of treatment it is considered similar to umbilical hernia.

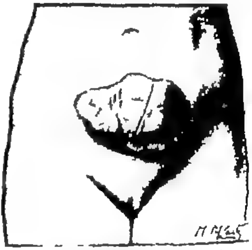


Fig. 720.—Strangulated incisional hernia. *Type* 2. The incision is made into that locule which feels more tense than the remainder.

A woman of 38 had a strangulated incisional hernia. Thirty-five years previously Lawson Tait had performed ovariotomy. Five days before I saw her the hernia had become more prominent, and she had vomited once. She had been treated expectantly. On examination, the skin over the hernia was acutely inflamed and surmounted by a gangrenous patch. At operation the sac was found to contain a coil of black, perforated intestine. The gut was resected and end-to-end anastomosis performed. She died two months later from pulmonary complications.

Other almost as striking examples of the masking of signs of obstruction have been noted in these cases of strangulated incisional herniæ. Therefore do not be misled by the lack of indisputable signs of acute intestinal obstruction. Conservatism in these cases usually spells disaster. Operate early.

Operation.—For purposes of operative treatment incisional herniæ may be usefully divided into two classes: (1) *Those with a reasonably defined neck.* (2) Large multilocular ones.

Type 1.—This may be considered as similar to an umbilical hernia, and the transverse encircling incision like that for Mayo's operation (see p. 510) may be used with advantage

(*Fig* 719). After the obstruction has been relieved, the abdominal wall can be repaired in a similar manner to the method used in Mayo's operation.

Type 2.—In large multilocular herniæ, on careful palpation it will usually be found that one loculus is more tense and tender than the remainder Make a vertical incision over this loculus (*Fig* 720) with great care, for as often as not, after the skin has been incised, it will be found that only a veil like sac separates the scalpel from a tense loop of intestine. In this type of case the surgeon should be content to relieve the obstruction and make no attempt to repair the hernia. In certain cases repair of the abdominal wall may be undertaken at a later date.

CONGENITAL STRANGULATED UMBILICAL HERNIA

The infant may be born with a strangulated umbilical hernia containing either a Meckel's diverticulum or a loop of small intestine. The late Sir L. Barrington Ward operated upon two cases of the latter variety The hernia was found to be filled with an enormously dilated segment of ileum which was everywhere adherent to the sac. The intestine was separated and a radical cure performed. Waugh recorded the case of an infant twenty four hours old with a strangulated umbilical hernia in which he successfully resected and anastomosed a segment of the small intestine

EXOMPHALOS

Practically all cases not operated upon die of peritonitis, and the sooner after birth the operation is performed the better

Through the transparent wall of the sac the viscera are exposed to view as if exhibited in a show-case (W E. Ladd) The first point to ascertain is Does the sac contain the liver or a portion thereof" for if so, operative treatment is more difficult. In about 40 per cent of cases the sac does contain some part of the liver and in about 25 per cent practically the whole of the liver is extra-cœlomic. Until comparatively recently it was believed that the presence of the greater portion of the liver in the sac constituted a hopeless prognosis. This is far from the case There is now recorded a number of examples of what may be termed exomphalos major where prompt operation has been perfectly successful.

Anæsthesia.—A skilfully administered general anæsthetic makes the operation less difficult. When the services of a skilled anæsthetist are not available, local infiltration with procaine preceded by premedication of 1 minim (0·06 ml.) of nepenthe and 1 gr (0·06 g.) of chloral hydrate is usually satisfactory During the operation the infant is allowed to suck dextrose water from a feeding bottle, and if the manipulations are gentle crying with its accompanying contraction of abdominal musculature is avoided.

ONE STAGE OPERATION FOR EXOMPHALOS

This procedure is indicated when the base of the sac is not more than 3 in. (7·25 cm.) in diameter and the sac does not contain a large portion of the liver

An incision is made in the skin ¼ in. (6 mm.) from its junction with the sac on the left hand side. The incision, which extends from about 2 to 6 o clock (*Fig* 721) is deepened until the peritoneum is reached. This is opened carefully and, keeping about ¼ in. (6 mm) from the sac the sac is excised with scissors. Three vessels will be encountered—two umbilical arteries and the umbilical vein. The umbilical arteries are fairly constant in position, viz., at 5 and 7 o clock (*Fig* 722) In exomphalos the umbilical vein is displaced upwards and is encountered at one or other side at about 3 or 9 o clock. Knowledge of the disposition of these vessels enables them to be clamped before they are cut.

The sac having been removed, the viscera are reduced into the peritoneal cavity and retained there with a warm, moist pack. The incision is extended superiorly and inferiorly for a short distance. The peritoneum is then dissected from the abdominal wall, and as its edges are being united, the pack is withdrawn. The musculature of the abdominal wall is united in two layers first the rectus muscles and secondly the sheaths of these muscles. The edges of the skin are then approximated. In order to lessen tension on the line of suture corsets are applied well away from the incision.

If a considerable portion of the liver is present in an exomphalos, and the case is treated by the method just described, not only is the operation very difficult but the

Fig. 721.—An incision is made through the skin on the left hand side of the sac a quarter of an inch from the junction of the sac with the skin.

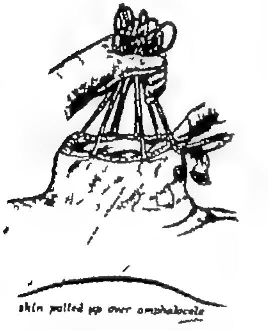
Fig. 722.—The usual disposition of the umbilical arteries and vein in cases of exomphalos.

prognosis is considerably less favourable. The reason for this is that force must be used to bring the abdominal wall together and overcrowding of the viscera results. Whenever the base of the sac is more than 3 in. (7·25 cm.) wide R. E. Gross strongly recommends the following two-stage operation, which is attended by much more favourable results.

TWO-STAGE OPERATION FOR EXOMPHALOS

Stage 1.—(*a*) The external surface of the intact sac is sterilized with tincture of iodine diluted to half strength with 70 per cent alcohol. (*b*) The umbilical stump is re-amputated near its junction with the sac and the cut end is sutured. (*c*) A circular incision is made through the skin at least ½ in. (1·3 cm.) from the amnio-cutaneous margin. On no account open the sac. (*d*) The skin and subcutaneous tissues are dissected off the aponeurotic layer of the abdominal wall (*Fig.* 723). The undercutting proceeds widely downwards towards the pubis, infero-laterally to the iliac crest, laterally towards the flanks, but upwards no farther than is absolutely necessary to provide a covering of skin for the contents of the amniotic sac. *It is of paramount importance that the undermining of the skin of the thorax be reduced to an absolute minimum.* (*e*) The sac, together with the attached rim of skin is excised. (*f*) The skin-flaps are lifted up with Lane's tissue forceps while the amniotic sac containing the viscera is depressed with a Sergeant's depressor or a bendable flat retractor.

A



B

C

Fig. 723.—A, Undermining the skin and subcutaneous tissue to permit them to be drawn over the sac. B, Pulling the mobilized skin over the amniotic sac. C, The operation completed. (*After R. E. Gross.*)

(*g*) The skin and subcutaneous tissues are united vertically (*Fig.* 723, A, B, C). Abdominal corsets are applied.

Stage 2.—Between three and eighteen months after the first operation the abdominal cavity becomes large enough to accommodate the viscera without overcrowding. That the time is ripe for the second operation can be verified clinically by demonstrating that it is possible to reduce the contents of the hernia into the abdominal cavity when the child is not crying. The second operation consists of dissection of the peritoneum from the abdominal wall, excision of the now redundant sac, closure of the peritoneum, and vertical closure of the abdominal wall in layers.

RUPTURED EXOMPHALOS

Frequently after the eviscerated intestine has been washed in saline solution it can be replaced, and the abdominal wall repaired with a fair prospect of success. Post-operative gastric decompression and parenteral fluid therapy should be continued until the bowels have acted. Penicillin, 30 000 units intramuscularly 6-hourly and streptomycin, 50 mg intramuscularly twice daily should be commenced as soon as possible and continued for at least seven days after operation. Prior to the antibiotic era, cases of ruptured exomphalos were almost hopeless. *The prognosis is better in cases where the rupture of the* evisceration occurred during, or after birth; when the rupture occurs *in utero* the intestines are oedematous and matted together and often fail to regain their peristaltic activity.

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CHAPTER XLI

JEJUNOSTOMY AND ILEOSTOMY

JEJUNOSTOMY FOR FEEDING PURPOSES

JEJUNOSTOMY can prove a life-saving measure in cases of duodenal fistula. It is also sometimes indicated fairly urgently in cases of carcinoma of the œsophagus when the intention is to resect the area bearing the neoplasm at a later stage

Construction of a Jejunostomy Tube.—A piece of rubber drainage tubing in good condition with a lumen of ⅙ in. (4 mm.) diameter is chosen. What is to be the inner extremity is cut off obliquely Two side holes are cut near this extremity A rubber collar cut from the outer end of the tube, is drawn on to the tube in the following manner an assistant stretches the collar with the open jaws of one hæmostat. With another hæmostat the whole thickness of the butt end of the rubber is grasped, in the manner shown in *Fig* 724 The tube is moistened and drawn onwards until the collar comes to rest 5 in. (12 5 cm.) from the whistle-tip The tube is then sterilized. Before commencing the operation the tube is transfixed midway between the collar and the whistle-tip by a needle carrying a No 1 catgut stitch (*Fig* 724 inset)

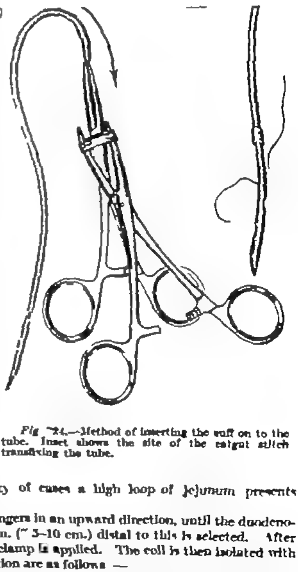


Fig 724.—Method of inserting the cuff on to the tube. Inset shows the site of the catgut stitch transfixing the tube.

Position of the Patient—The left hypochondrium is raised a little as compared with the right, by tucking a folded towel beneath the lower costal region.

The Operation —Local infiltration anæsthesia is used. An incision not more than 2 in. (5 cm.) long is made just posterior to a prolongation of the anterior axillary line, beginning at the tip of the eleventh costal cartilage (*Fig* 725) The incision is carried down to the peritoneum through the external oblique, internal oblique and transversus muscles, with no regard to the direction of their fibres. The peritoneum is opened for a distance of about 1 in. (2 5 cm.) In the majority of cases a high loop of jejunum presents immediately (*Fig* 726)

The small intestine is run through the fingers in an upward direction, until the duodeno-jejunal flexure is reached, and a point 3–4 in. (7 5–10 cm.) distal to this is selected. After the coil has been emptied, a light intestinal clamp is applied. The coil is then isolated with warm, moist packs. The steps of the operation are as follows —

1 The antimesenteric border of the intestine is picked up in a hæmostat. A second hæmostat is placed in juxtaposition. The intestine is merely nicked between these two instruments. Disconnecting one of the hæmostats, it is used to enlarge the opening just sufficiently to permit the introduction of the tube This hæmostat being soiled is discarded

2. A needle is threaded on to each end of the catgut suture and each is passed through the whole thickness of the intestine from within, outwards, using a needle holder The needles, the hæmostat, and the needle holder are discarded because they are soiled.

The suture is tied and its ends cut short. Gloves, soiled by tying the suture are changed

3 A purse-string suture of non-absorbable material encircles the intestine a short distance from the tube. It is tied while the tube is pressed gently towards the intestine. The ends of this suture are cut short.

4 A second purse-string suture is inserted likewise The ends are left long.

5 Another (ordinary) stitch is passed through the gut wall near the exit of the tube opposite the knot of the purse-string suture Thus we have four long ends arranged in two pairs.

6 The end of the tube is passed through an available piece of greater omentum.

7 Each of the four long ends is in turn threaded on to a needle and each is passed through the omentum from its deep to its superficial surface, about ½ in. (12 mm.) from the tube. These ends are tied in pairs (*Fig* 727). This anchors the omentum firmly on to the intestinal wall in the region of the tube. *The long ends are still left long.*

8. Each long end is yet again threaded on to a needle. No. 1 is passed through the edge of the peritoneum on the right No. 2 is passed through the edge of the peritoneum on the left Nos. 3 and 4 are dealt with similarly In this way there are two pairs of stitches, one above and one below the tube and when these are tied they will fix the intestine with its omental reinforcement hard against the under surface of the peritoneum but the stitches are not tied at this stage—they are clipped in their respective pairs while the peritoneum is closed about the tube. Finally the two pairs of stitches are tied, and this time their ends are cut short.

9 The abdominal wall is closed about the tube. The rubber collar is pulled along the moistened tube towards the skin as shown in *Fig* 728 A stitch is passed through the skin and the collar and tied (*Fig* 729). This fixes the tube without penetrating its lumen. Infection of the wound cannot occur from leakage through a stitch-hole in the tube

10 It is a wise precaution to insert two stitches, as shown in *Fig* 730 around the tube

Jejunal Feeding —It is essential that the patient receives an adequate intake of liquid nourishment, and in addition he should receive vitamins. It is also most important to order that the bile, etc., collected from the fistula should be given back to the patient through the jejunostomy tube it is surprising how beneficial this is.

For the first twelve hours 5 per cent dextrose solution is given by the drip method at the rate of 2¾ fl. oz. (80 ml.) per hour At the end of twelve hours pabulum feeding is commenced.

Pabulum Feeding —Consistently good results have been obtained employing the following mixture —

Skimmed milk	17½ fl. oz. (500 ml.)
One egg	

The skimmed milk and the well-beaten egg are peptonized, and the vitamins (see below) are added. By substituting skimmed, for full-cream, milk, the tendency to diarrhoea is greatly diminished.

Vitamins.—The daily requirement of various vitamins, is as follows

Ascorbic acid	50 mg
Multivite (British Drug Houses)	2 pellets
Benerva compound (Roche)	1 tablet
Riboflavin	2 mg

The above vitamins are crushed and added to the feeds. One gramme of calcium per day should also be given (C. A. Birch).

At first the pabulum is allowed to drip so that 14 drachms (50 ml) are introduced into the jejunum each hour The drip feed requires the attention of the nurse to see that it is running and at a proper speed. During the next twenty four hours the amount of pabulum is increased to 3½ fl. oz. (100 ml) per hour and this is continued day and night. Naturally the amount and the rapidity with which it can be introduced will vary with the individual and no set rule can be used for all cases, but the aim should be to introduce between 3½ and 5¼ pints (2000 and 3000 ml.) each twenty four hours. Unless the pabulum is introduced slowly at the commencement, the patient will have abdominal distress, and he may experience nausea, vomiting, colic, and diarrhoea. The latter may be controlled by the addition of small doses of paregoric (Tinct. opii camph).

JEJUNOSTOMY

Fig 725 —Haydm s ncision for jejunostomy

Fig 726.—The tube is inserted into the lumen of the gut through a tiny stab incision. Having been anchored to the intestinal wall with a stitch, the tube is invaginated by two purse-string sutures, the ends of each being left long

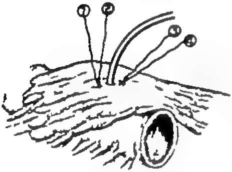


Fig 727 —The tube is brought through a portion of the greater omentum. The long ends of the sutures are likewise brought through with a needle and then tied in pairs.

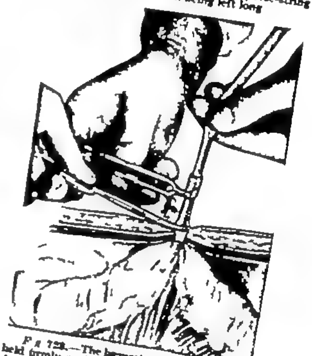


Fig 728.—The hemostat clipping the tube is held firmly again t the skin while the collar is drawn down the lubricated tube

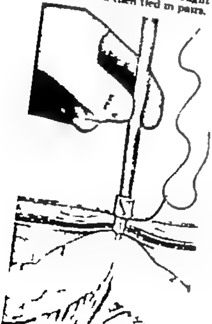
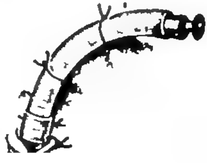


Fig 729 The colla is st tched t the skin thus obviating penetration of the tube proper



ILEOSTOMY FOR DRAINING OBSTRUCTED SMALL INTESTINE

Ileostomy (*syn* enterostomy) so often practised in the past as an adjuvant measure in obstruction to the small intestine and as a means of relieving paralytic ileus (it seldom succeeded), is practically obsolete. In the absence of a balloon-ended tube, or failure to pass it and in the presence of intestinal obstruction caused by multiple adhesions with the patient in very poor condition, ileostomy is still of service. If performed by the aseptic technique in exactly the same manner as jejunostomy just described the operation can prove life-saving

TERMINAL ILEOSTOMY FOR ULCERATIVE COLITIS

This is sometimes a quasi-emergency The fulminating type of case that fails to respond to the usual medical treatment including cortisone (300 mg daily) is the one in which the surgeon's assistance is likely to be sought It should be noted that the danger of the continued use of cortisone is hæmorrhage from or perforation of an unsuspected

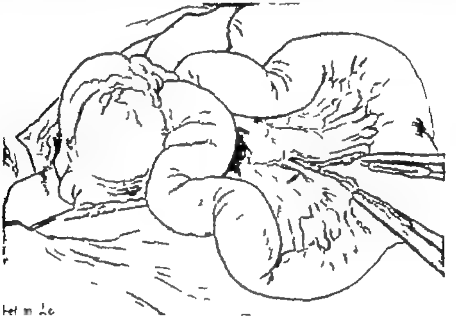


Fig 731 —Division of the ileum The mesentery is divided as far as possible without severing a main blood vessel.

peptic ulcer or perforation of the colon itself Proctoscopy in order to obtain a scraping from the rectal wall, may be necessary to rule out amœbic dysentery (*see* p. 1002).

Pre-operative Treatment.—Dehydration must be corrected by intravenous fluid therapy and if as is usual, the hæmoglobin level is below normal, blood transfusion should be given. If it is permissible to postpone operation for two or three days, the opportunity is taken to harden the skin of the abdominal wall by the application of tannic-acid jelly The bacterial flora of the intestine can be reduced by giving 1 G of neomycin and 1·5 G. of phthalylsulphathiazole 4-hourly up to a total of 10 G of neomycin and 15 G. of phthalylsulphathiazole

Operation.—*A right*[1] *lower paramedian incision is made. The colon* is palpated to exclude supervention of a carcinoma in any part of it carcinoma is not an uncommon complication in long-standing cases of ulcerative colitis. A disk of skin 1¼ in. (3 cm.) in diameter is removed 2 in. (5 cm.) lateral and 1½ in. (3·8 cm.) below the umbilicus (*Fig.* 732 A, B). The right side of the abdominal wall is then held up with retractors, so that its peritoneal lining can be seen. A stab is made through the centre of the circular incision directly through all layers of the abdominal wall and the peritoneum (*Fig* 732 C). The opening is enlarged with the fingers to such a size that it can accommodate the divided

[1] A left lower paramedian incision has the advantage that the laparotomy wound and the resulting scar is not in the immediate vicinity of the rim of the ileostomy bag; consequently better adherence to the skin is obtained (A. White).

ileum and its mesentery without compressing them. Returning to the param incision two small Payr's intestinal crushing clamps are made to grasp the ileum a its transverse axis 6 in. (15 cm.) above the ileocæcal valve. They are applied har against one another. The ileum is divided between these clamps with a diathermy

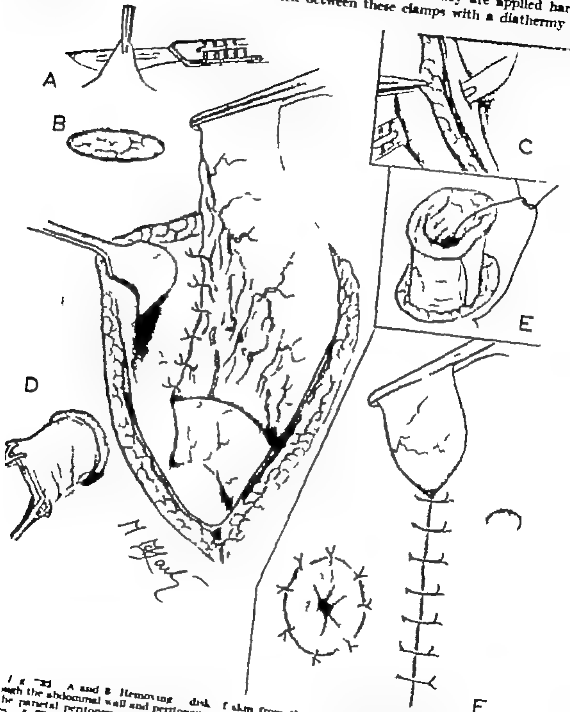


Fig. 731. A and B, Removing disk of skin from the abdominal wall; C, Stab incision through the abdominal wall and peritoneum. D, Method of sewing the cut edge of the mesentery to the parietal peritoneum. E, Suturing the free extremity of the proximal ileum to the skin edges. F, The operation completed.

aut ry and the cut ends protruding from the clamps are sterilized most thoroughly by t at agulation. The mesentery is divided between hæmostats (*Fig.* 731), and ligated securely. A long hæmostat (or better two Babcock's tissue forceps), is passed through th circular incision and it jaws are made to grasp the proximal cut end of the ileum after r moval of the crushing clamp. Contrary to what might be expected the crushed intestine does not open and pour forth it contents. The proximal end of the divided intestine b

drawn through the circular incision, and about 2 in. (5 cm.) of the intestine is allowed to protrude (*Fig* 782 D). The distal end of the intestine with its clamp attached, is made to emerge through the extreme upper end *of the main incision.* A most important step is to close the space on the lateral aspect of the emerging loops, to avoid the risk of an internal hernia. This is effected by suturing the cut edges of the mesentery of the proximal and *distal* segments to the parietal peritoneum (*Fig* 782 D). An additional advantage of this procedure is that it helps to prevent subsequent prolapse of the mucous membrane, which is otherwise prone to occur through the proximal ileostomy opening. The laparotomy incision is closed, leaving 2 in. of the distal ileum protruding from the extreme upper end of the incision. The laparotomy wound itself is protected by sewing on a dressing of gauze *soaked in Tinct.* benzoin co. or a similar adhesive fluid. The distal end of the ileum, with the clamp attached, is covered with gauze

Attention is now directed to the terminal ileostomy After arranging packs on either side of the protruding intestine, the hæmostat is removed and the mouth of the gut is prised open. As much as possible of the fluid fæces is aspirated with a sucker The packs are *then removed, and, after excising the crushed fringe of the intestine,* the free extremity of the proximal ileum is sutured with interrupted catgut stitches to the skin edges (*Fig* 782 C). An ileostomy bag is applied forthwith. The best type of bag is the Clifron disposable bag [1] and the best method of making a long lasting water tight junction is to fix the bag to the skin with double-sided adhesive plaster

Post-operative Treatment.—For *several days fluid and electrolytic* balance *must* be adjusted with great care. During the early post-operative period very large quantities of salts and water are liable to be lost and must be replaced accurately To combat anæmia, which is often serious, multiple small transfusions are more effective than large less frequent, ones. Transfusion should be continued until the hæmoglobin has reached a level of about 80 per cent. Liver extract, given parenterally is also indicated. Excoriation of the skin by liquid fæces can be minimized by giving isogel by mouth. The skin of the abdominal wall requires great attention to prevent excoriation, some degree of which is inevitable Silicone barrier cream (vasogen)[2] or a paint of aluminium 10 parts and zinc oxide 90 parts are perhaps the best of many applications recommended for this purpose

Of great value are vitamins A B, C D and K Vitamin D is especially required because of the low content of fat in the diet. Vitamin K may help to control the bleeding Phthalylsulphathiazole is administered in large doses, 1 G (15 gr) four-hourly for six weeks. Alternatively neomycin can be substituted. In the absence of this antibiotic, aureomycin can be given, with a view to reducing infection.

The stools thicken in a few weeks, and are usually semi-solid in a few months. As soon as the patient's general condition improves, the advisability of performing colectomy must be given due consideration.

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[1] Down Bros. Ltd., London.
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muscles, anteriorly by the urogenital triangle posteriorly by the sacrum and coccyx. These structures are invested by a covering of rigid fascia, and if pus, blood, or urine distends the infraperitoneal space expansion is limited everywhere except superiorly where it communicates with the retroperitoneal space. These anatomical details explain the necessity for free dependent drainage of the perirectal cellular tissues in cases of extra peritoneal perforation of the rectum

Diagnosis.—When the patient gives a history of rectal impalement, on no account underestimate the probable gravity of the injury. The first interrogation should always be directed to the bladder. Has the patient passed urine since the accident? Information that blood has been passed per rectum or in the urine, or that urine was passed per rectum or per vaginam is, of course, ominous.

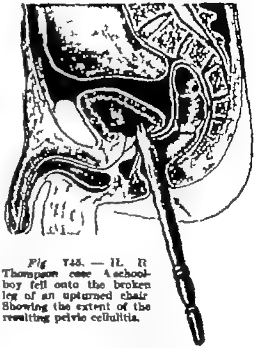


Fig 748. — H. R Thompson case A schoolboy fell onto the broken leg of an upturned chair Showing the extent of the resulting pelvic cellulitis.

Having inspected the anus, the abdomen is examined. If there is any evidence of rigidity or tenderness, the decision to explore the left lower quadrant of the abdomen should be made without hesitation. It is, however necessary to pass a catheter. If the urine is blood-stained or shows more than 6–8 red cells in the low power microscopical field, it is most desirable to undertake cystography after gravitating a contrast medium (e.g. uriodone) into the bladder. Definite proof that the bladder is perforated will alter the operative programme. In any event, a plain radiograph of the abdomen is valuable to confirm or eliminate the presence of free gas in the peritoneal cavity

When abdominal rigidity and tenderness are entirely absent reliance must be placed on a digital examination of the rectum. If an undoubted perforation can be felt, this combination of signs—and this combination only—is an indication for exploration from below

Some surgeons recommend sigmoidoscopy as a means of establishing the diagnosis. There are weighty objections to this course. In the first place it is usually unnecessary and secondly if a perforation is present inflation must result in pumping air and fæcal matter into the peritoneal cavity or the retroperitoneal space.

Pre-operative Treatment.—Peripheral circulatory collapse if present, must be treated. Antibiotic therapy should be commenced immediately. The administration of antitetanic and anti-gas-gangrene sera is important seeing that it is well known that tetanus infection frequently results from such injuries of the bowel. Operative treatment should be delayed only until the condition of the patient justifies a general anæsthetic being given without added risk

AVENUES OF APPROACH AND STEPS OF THE OPERATION

1 **Suprapubic Cystostomy.**—If the bladder is certainly perforated, commence by performing suprapubic cystostomy. Open the bladder sufficiently widely to obtain a good view of its posterior wall. Suture the perforation with catgut stitches, but do not pass them deep enough to include the rectal wall. Close the cystostomy wound around a ½ in. (1·3-cm.) drainage tube. Drain the cave of Retzius with a corrugated rubber drain. Cover the wound securely

2. **Laparotomy.**—Open the abdomen by employing a left paramedian incision. Aspirate free fluid and pack away coils of small intestine. Have the operating table tilted into moderate Trendelenburg's position

a An Intraperitoneal Rupture of the Rectum is found.—Close the perforation with two layers of sutures, the outer being of cotton. It is most necessary to examine the small intestine for a second perforation, which has been present in several reported cases; incidentally the mesentery may be found to be torn. *Drain the peritoneal cavity* If suprapubic cystostomy has been performed the best method is to place two Penrose drains

in the rectovesical pouch, and bring them out through the lower end of the laparotomy incision.

b. An Intraperitoneal Rupture is not present, but there is Blood beneath the Pelvic Peritoneum.—It is imperative to explore the retroperitoneal portion of the rectum. This can be accomplished by incising the lateral and medial reflections of the parietal peritoneum distal to the sigmoidal branch of the inferior mesenteric artery and uniting these incisions *anterior to the rectosigmoidal junction.* This manœuvre mobilizes the rectosigmoid and permits a good deal of the rectum to be drawn upwards, thus enabling a perforation of the rectum below the pelvic diaphragm to be seen, and closed securely. A perforation in the bladder can also be sutured or if sutured already can be reinforced. The peritoneum is then re-attached to the bowel above the perforation.

3. Left Iliac Colostomy is performed through a separate gridiron incision (see p. 441). The necessity for this step is conceded generally. A few surgeons state that in very early cases this step can be omitted. If both colostomy and suprapubic drainage of the bladder have been necessary a water-shed dressing (see p. 452) should be applied.

Fig. 746.—Para-sacrococcygeal incision for entering the infraperitoneal space. *It is desirable to remove a narrow ellipse of skin, as shown.*

4. Perineal Stage of the Operation.—The patient is placed in the exaggerated lithotomy position (see *Fig.* 746).

When there is a lacerated perianal wound involving the sphincters, the perineal stage of the operation should commence with thorough débridement with excision of devitalized areas of the sphincteric muscles. Careful suture of the muscles involved is then undertaken.

Entering the infraperitoneal space. Adequate exposure of this space can be obtained by an incision parallel to the lower half of the sacrum and the coccyx (*Fig.* 746), dividing the fibres of the gluteus maximus near its origin. Excision of the coccyx *is unnecessary* and undesirable. The fascia propria of the rectum is incised, the space is entered, and all blood and clot evacuated. A sharp look-out must be kept for pieces of clothing that are often driven into the para-rectal space. A soft drainage tube[1] is passed into the hollow of the sacrum, and the skin edges are approximated lightly around this.

5. Insertion of an Indwelling, Intrarectal Tube.—The external sphincter is dilated and a soft rubber tube is passed through the anus so that it reaches 2–3 in. (5–7.5 cm.) above the level of the perforation. The tube is anchored by a stitch to the perianal skin.

When the Perforation is situated within the Reach of the Finger and there are No Signs of Peritoneal Involvement the perineal stage of the operation described above is alone necessary. The perforation must always be sutured and a temporary left iliac colostomy performed. If such a perforation is left unsutured it is liable to reopen when the colostomy

[1] *Drainage of the subperitoneal space* by double tube suction drainage (see Chapter XCIII) is an effective method of preventing infection of the hæmatoma.

is closed, thus leaving the patient in the unfortunate predicament of requiring a second colostomy and repair of the perforation of the rectum.

After-treatment.—Antibiotic treatment should be continued as long as necessary. If suprapubic drainage of the bladder has been carried out, sump drainage (see p 189) is most desirable. A colostomy can be closed in 6–8 weeks.

ISCHIORECTAL WOUND

A puncture wound of the ischiorectal fossa with damage to the levator ani, but without perforation or injury to the rectum or urethra should be explored by careful dissection. After débridement, the cavity is packed lightly.

PERFORATION OF THE RECTAL WALL BY THE RIGID NOZZLE OF A HIGGINSON'S SYRINGE

The cases in the literature fall mainly into two groups: (1) Persons in and above the sixth decade and (2) Pregnant women at term. Perforation of the normal rectum of a conscious patient can take place without the patient experiencing much pain, and without the use of much force. This is especially true of the older age groups. Of 20 cases reported in the literature 12 were extraperitoneal, with 3 deaths; and 8 were intraperitoneal, with 8 deaths.

The treatment differs in no respect from that described for impalement of the rectum.

PERFORATION OF THE RECTUM WITH THE SIGMOIDOSCOPE

This unfortunate accident has occurred many times. In ulcerative conditions, even the air distension may cause the floor of an ulcer to give way. More often the perforation occurs through the end of the instrument being advanced without clearly seeing the lumen of the bowel ahead.

Provided the accident is realized at once and the perforation is sutured, the prognosis is good. Particularly if the rectum and lower colon are the seat of a pathological process, it is a wise precaution to perform colostomy and thus rest the sutured area.

H. B. Walker's Case.—

A man, aged 28, was admitted to a British Military Hospital with amœbic dysentery. Routine sigmoidoscopy carried out by an experienced medical officer revealed two small superficial ulcers in the upper part of the rectum. Six hours later the patient complained of severe abdominal pain, and by this time the patient was very ill, the pulse-rate 130, and the abdomen considerably distended. Laparotomy was performed as soon as the general condition of the patient allowed, and on incising the peritoneum gas escaped. There was widespread fæcopurulent peritonitis. A perforation was found at the rectosigmoid junction, through which gas and liquid fæcal matter were escaping. The perforation was closed by sutures, and reinforced by an omental patch. Cæcostomy was carried out because there was a short mesocolon which would have rendered exteriorization of the pelvic colon difficult. A large rectal tube was inserted into the rectum and manœuvred into the pelvic colon. This was secured to the anus by a stitch. The abdomen was closed with drainage. The patient recovered. It was considered that probably air insufflation during sigmoidoscopy was the cause of this perforation.

PILLION RIDER'S ACCIDENT

In the case of a young girl with what has become known as pillion-rider's accident I found extensive laceration between the rectum and the vagina, and the vagina and the bladder. In addition to suturing the rent in the bladder transvesically and carrying out suprapubic cystostomy, left iliac colostomy was performed. Three weeks later the suprapubic opening was allowed to close. After several months it was possible to close the colostomy.

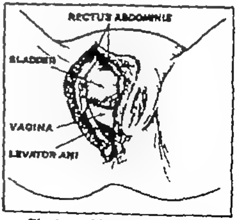


Fig. 747.—Diagram of the operative findings in Duff Mitchell's case of pillion-rider accident.

In Duff Mitchell's case there was a compound fracture of the pelvis (Fig. 747). After excision of the wound the fractured pubic bone was drawn together with silver wire. The two heads of the rectus abdominis were united with sutures, and the levator ani and the external sphincter repaired similarly. The

bladder was not ruptured, but contained blood-stained urine so a self retaining catheter was left in situ. The skin was united allowing for adequate drainage

FOREIGN BODY IN THE RECTUM

By accident depravity or imbecility foreign bodies become lodged in the rectum beyond the recall of the patient. The variety of these foreign bodies is hardly less remarkable than the ingenuity displayed by surgeons in removing them. Fenwick delivered a turnip by way of the anus, using obstetric forceps; J C. Robb successfully extracted a 4-oz. (120-G) bottle by the same means. Leber finding that a stick could not be withdrawn, inserted a gimlet into its lower end. With the additional leverage thus obtained the stick, 12 in. (30 cm) in length, was extracted successfully E. A. Diggins, being confronted with a man who had in his rectum a tumbler the bottom of which was nine inches from the anus stuffed the interior of the glass with gauze dipped in plaster-of Paris paste. The last strip was sufficiently long to hang outside. In half-an hour s time the plaster had set and Diggins successfully pulled out the glass. This ingenious method, which was originally suggested and practised by Le Fort, should be tried in every instance of a wide-mouthed *receptacle looking downwards.*

Ingested foreign bodies may become impacted in the rectum —

A girl of 17 was admitted with subacute intestinal obstruction. So great was the spasm of the anal sphincter that an anæsthetic had to be administered; even then it was necessary to employ Hegar s dilators before the rectum could be examined effectively Following this procedure, 231 cherry stones were retrieved. Fourteen days previously the girl had been employed as a cherry picker (P Berry)

When the Foreign Body cannot be Delivered from Below —If considerable difficulty is encountered in getting hold of the object in the rectum, the abdomen should be opened on the left side in a manner similar to Battle s incision. This gives easy access to the pelvic colon. The surgeon, with a hand in the abdomen can as a rule squeeze the object downwards to the assistant, who awaits its accessibility for extraction through the anus. In the only instance in which I performed this type of operation (for a gall-stone), I gained the impression that it is preferable to resort to laparotomy at the first sign of real difficulty

Even when the abdomen has been opened it may be impossible to pass the object downwards—a very rare event.

P R Hare s Case —

A man, aged 55, who was admitted to the Northern Hospital, Liverpool, had suffered from a rectal prolapse for many years which recently had become difficult to reduce. He was advised by his friends to try to reduce it by pressure with the bottom of a ½-lb. (225-G.) jam jar and by some extraordinary mischance forced the jar up past the tubera ischii into the rectum. He attempted to remove the jar himself, but failed, and it was not until three days later that he visited his doctor Even with anæsthesia and the use of all available forceps and retractors it was found impossible to extract the jar Laparotomy was therefore performed, and an attempt was made to pass the jar downward but without success It could not be manœuvred past the ischial plane After completely isolating the area with packs, a longitudinal incision was made in the pelvic colon and through this the jar was extracted. The opening was closed transversely and a corrugated rubber strip passed down to the suture line Left iliac colostomy was then performed. In three weeks time the rectal condition had returned to normal, and the colostomy was closed.

ANORECTAL ABSCESSES

Fistula-in-ano is a common condition. Because most of these fistulæ are an aftermath of inadequate treatment of anorectal suppuration, anorectal abscess is a subject that demands close attention by the emergency surgeon. In this instance inadequate operations are neither the result of lack of experience nor want of manual dexterity on the contrary they are the direct outcome of sheer lack of knowledge Too much reliance in antibiotics, fomentations—waiting for the abscess to ripen —a short incision—more fomentations this is the unholy sequence of events that invites fistula formation. The most reprehensible practice is to open an ischiorectal abscess by Hilton s method.[1] I have seen a case at necropsy where this had been done; evidently the forceps had penetrated the apex of the ischiorectal fossa, for widespread retroperitoneal cellulitis had resulted.

[1] A short incision followed by plunging in sinus forceps and opening their jaws.

So much for what should not be done.

Bacteriology.—The presence of stinking pus usually indicates the presence of *Bact coli*. Bacteriological examination of the pus, however, shows that *Staphylococcus aureus* is present in about three out of five abscesses (M. Ellis).

VARIETIES OF ANORECTAL ABSCESSES

Cellulitis of the tissues around the anal canal rarely resolves completely. Pus forms early and occupies one (sometimes more) of the following situations:—

1. **Perianal Abscess** (*Fig* 748) is eight times more common than an ischiorectal abscess. The perianal space is bounded inferiorly by skin, superiorly by the perianal fascial septum, medially by the subcutaneous external sphincter and laterally the space becomes continuous with the subcutaneous tissues (*Fig* 749).

Fig 748.—Perianal abscess. Observe the cellulitis extending to the ischial tuberosity (*E. S. R. Hughes*.)

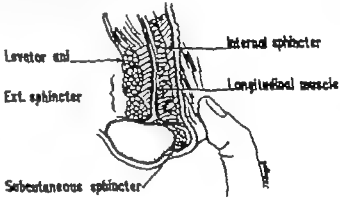


Fig 749.—The relations of a perianal abscess. (*After E. S. R. Hughes*.)

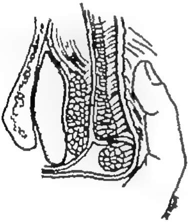


Fig 750.—Ischiorectal abscess. The upper level of induration extends above the level of the anorectal ring—an important diagnostic feature. (*After E. S. R. Hughes*.)

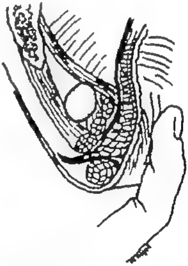


Fig. 751.—Relations of a post-sphincteric abscess. (*After E. S. R. Hughes*.)

2. **Ischiorectal Abscess** occupies the ischiorectal fossa (*Fig* 750). The ischiorectal space communicates with that of the opposite side via the post-sphincteric space. The constitutional symptoms of an ischiorectal abscess are more pronounced than in other varieties of anorectal suppuration. In comparatively early cases there is no redness of the skin.

3. **Post-sphincteric Abscess** is often small, but if it is allowed to spread it does so into both ischiorectal fossae with which it is anatomically continuous. The post-sphincteric abscess lies rather deeply between the coccygeal attachment of the levator ani above and the coccygeal attachment of the superficial part of the external sphincter below (*Fig* 751).

4. Submucous Abscess.—Doubtless a submucous abscess often bursts sponta When present it presents as a tender swelling of the anal canal extending downward anal *groove, and often to well beyond the anorectal ring* Occasionally it extends perianal space, giving rise to an bilocular abscess (*Fig.* 732).

Fig. 732.—An upward extension of the suppuration under the mucosa feels like a pencil.

TREATMENT OF ANORECTAL ABS

Indications for Operation.—*It i* generally that in the case of an abscess the operation should be un as soon as convenient after the diag been made. A tender brawny swelli side of the anal canal, as elicited by p between the finger and the thumb, is indication that operation is necessary

Pre-operatively.—*Half an hour b* operation 500,000 units of penicillin a of streptomycin are given intramusc *1–2 G* of aureomycin intravenously with the premedication favoured anesthetist.

Standard Operative Procedure.—F thesia is required the operation n be attempted under a short-acting an which causes the operator to feel hurried. The patient is placed in the lithotomy and if, as is often the case (because of tenderness of the parts), shaving h *inadequately performed this is remedied before other skin* preparation receives a The seated surgeon then examines the region with the object of not only evacuat but of preventing a fistula.

The situation of the abscess (induration) can be defined by palpation betw finger within the rectum and the thumb externally In a high percentage of cases reaches the perianal tissues through a lesion of one of the valves of Ball, and a opening in the mucosa can often be found if looked for especially The opening lies (2 5–3 8 cm.) from the anal verge and a common mistake is *to search for it too high. A teaspoon is a useful retractor* when making this examination. If pus is not exuding from the tiny opening often it will do so when a probe has been inserted into it. On no account should the probe be introduced forcibly the track usually runs not directly laterally above the external sphincter but downwards under the mucous membrane and then laterally The end of the probe, therefore, must be bent at an acute angle (*Fig* 733) if the track under the mucosa is to be followed. From time to time an indurated vertical ridge which feels like a pencil can be palpated. This is an *upward* extension of the suppuration *under the mucosa, and it ends blindly at varying distances* up to one inch (2 5 cm.) or more above the internal sphincter (*see Fig* 732). If a very troublesome form of fistula is to be prevented it is *just* as important to drain this extension

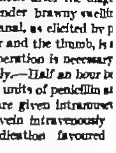


Fig. 733.—The tr ing from the tiny openi mucous membrane wa of all passes downwar the mucous membran

adequately as to attend to the ischiorectal abscess proper Fortified with exact d surgeon now changes his gloves, for this is not an occasion for haste. A liberal + incision is made into the abscess. The length of the incisions should be at leas the depth of the abscess (W F Gillespie) An adequate portion of skin, that include if not all, of the floor of the abscess, is excised (*Fig* 734 inset). The cavity is e and if septa exist they should be broken down gently with the finger and what important is that the granulation tissue lining its walls is removed by a finger w in gauze. *If this is not done antibiotics* administered systemically cannot re abscess cavity In cases where an internal opening is located, *and the opening i the external sphincter* the bridge of tissue intervening between the opening and the p

skin is severed. The resulting operative cavity may then be likened to a pear the body of the pear is represented by the excised skin and the stalk of the pear by the slit up mucous membrane (*Fig* 754)

Post-operative Dressing.—The whole cavity is very lightly packed with gauze wrung out in 2½ per cent Milton, or 1 : 2000 bradosol[1] solution If neither of these is available acriflavine emulsion is suitable. A T-bandage is applied.

After-treatment.—Antibiotic treatment is continued for a week or longer if necessary The cavity is irrigated daily preferably with 1 2000 bradosol solution, and a flat, moist dressing or very light packing is renewed. Antiseptic hip baths can be commenced

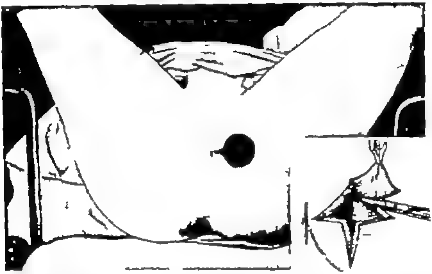


Fig 754.—Excising the skin overlying the floor of the ischiorectal fossa. The four flaps resulting from a cruciform incision are dissected free and removed. The completed operation leaves a pear-like deficiency The body of the pear is represented by the skin deficiency while the stalk is the slit up mucous membrane.

on the third day in most instances. After a week the cavity is usually lined with healthy granulation tissue. Healing is rather slow When the cavity is filled with granulation tissue skin-grafting expedites final epithelialization.

Variations in Operative Procedure to meet Special Circumstances.—

1 In the somewhat unusual event of a pencil-like submucosal extension of the abscess being present it is necessary to pass a director along the track and to lay it open. Brisk hæmorrhage is to be expected, and it is difficult to apply ligatures. In cases of difficulty hæmostats having been applied, they should be left in situ for 48 hours rather than persist in ineffectual attempts to ligate inaccessible bleeding vessels.

2. On still rarer occasions an internal opening will be found communicating with the ischiorectal fossa above the external sphincter When this is the case on no account should the musculature superficial to the fistula be divided at this stage. The track can be located later if a stout unabsorbable ligature is passed through it and out through the anus, and the ends are knotted 1 in. (2 5 cm.) from the anal verge so as to allow plenty of slack (Sir Charles Gordon Watson).

3. When the abscess is bilateral both sides should be opened by the technique described. The communicating track which invariably runs posterior to the anus, is laid open.

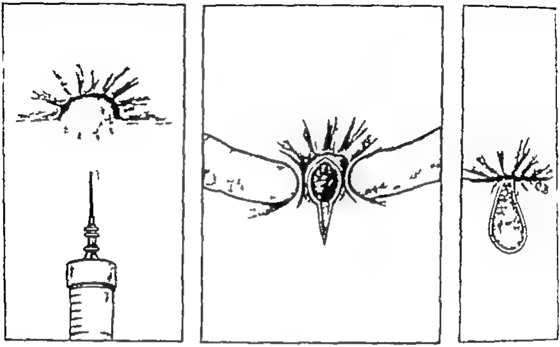
4 In the rare event of the case proving to be one of a pelvirectal abscess, and pus being found coming from above the levator ani the opening in the apex of the ischiorectal fossa is enlarged with a finger and a drainage tube inserted. Otherwise a drainage tube is not employed.

EMERGENCIES CONNECTED WITH HÆMORRHOIDS

The Thrombotic External Pile.—The so-called thrombotic pile is due to the bursting of an anal venule A swelling, aptly likened to an over ripe cherry is observed on one side of the anal orifice When the patient comes under observation on the first or even

[1] Bradosol. Ciba Laboratories Ltd., Horsham, Sussex.

on the second day of the attack he will be spared much inconvenience and pain if the condition is treated as an emergency The perianal skin having been sterilized, 1 per cent procaine is injected into the skin flanking the pile (*Fig* 755 A), after which the tissues beneath the hæmatoma are infiltrated. The hæmatoma is then incised and the clot squeezed out (*Fig* 755 B). With scissors, the undermined skin is excised, leaving a flat, raw area (*Fig* 755 C) Sulphonamide-penicillin powder followed by tulle gras is a suitable



A B C

Fig 755.—The emergency ambulatory treatment of a thrombotic pile (anal hæmatoma) The patient is in the lateral position. A, Injecting local anæsthesia. Note the injection is commenced some distance from the hæmorrhoid. B, Squeezing out the clot. C, Flat, raw area left after excision of all undermined skin.

first dressing Instructions to wash the parts after defæcation for at least a week and the provision of a supply of dry antiseptic dressings complete the treatment. When the patient presents more than 48 hours after the onset and the condition is subsiding no operation is advised. The parts are kept clean and covered with a dry dressing Resolution is often followed by a skin tag

Hæmorrhage after Operation for Internal Hæmorrhoids.—When I was acting as a pathological assistant, a male subject, aged 44 came to necropsy An operation for internal hæmorrhoids had been performed three days previously The whole of the large gut from the cæcum to the sphincter ani was full of blood. A clinical note stated that there had been no external hæmorrhage J F Binnie in his *Operative Surgery* disparages the use of a rubber tube wrapped in gauze as a dressing after operation for hæmorrhoids. "This dressing" he says, "ought to be reserved for personal enemies and malefactors, as it does no good." Had this tube dressing been employed in the case just cited, it might have been instrumental in saving the patient life for the blood, instead of remaining concealed in the colon, would have appeared externally

Fig. 756.—Perrin's slotted rectal speculum.

Some years ago I was summoned in the middle of the night to a woman who had had hæmorrhoids removed during the previous afternoon Through the drainage tube which had been placed in position blood had continued to drip, and the pulse was rising steadily in spite of the morphine which had been given. A general anæsthetic was administered, and a slotted rectal speculum (*Fig* 756) inserted through the sphincter

With a headlight the interior of the rectum was examined. A spurting vessel was discovered at the top of one of the suture lines. The bleeding point was caught with a long hæmostat and ligated. A tube wrapped in gauze soaked in glycerol was inserted through the anus. Recovery followed.

When the type of speculum illustrated above is not available or when a bleeding point cannot be found, recourse must be made to packing. After irrigating the rectum, a piece of half-inch rubber tubing, around which has been wrapped firmly a suitable length of gauze, is introduced into the rectum via a proctoscope (*Fig* 757). The proctoscope is removed and after some traction on the plug, the gauze is brought into intimate contact with the hæmorrhoidal region and further bleeding is thus controlled. The rubber tube surrounded by gauze should remain in place for 48 hours. Seldom is it necessary to have to re-apply the packing. In this connexion the following case is of interest

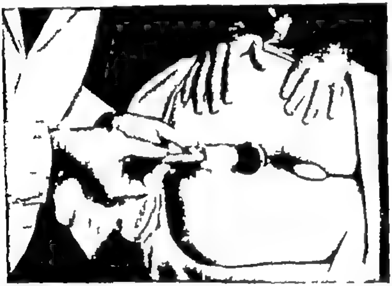


Fig. 757.—Introducing a rubber tube surrounded by gauze into the rectum through a proctoscope. When the plug is satisfactorily in position, a large safety pin is inserted through the protruding end of the rubber tube.

Mrs. I. P., aged 43, had internal hæmorrhoids removed. She gave a history of rectal hæmorrhage and obvious internal hæmorrhoids were present. Nothing disturbed the even tenor of the convalescence until the seventh day, when she passed a pint of bright red blood with the motion. The bleeding continued, and was considerable. Blood transfusion was given, and the anal canal was packed in the manner described above. A few hours later blood commenced to flow steadily through the drainage tube, and the hæmoglobin estimation at this time registered 55 per cent. After further transfusion and irrigation of the rectum with saline, the patient was taken to the operating theatre. The area of the operation appeared in perfect order. Through a proctoscope a solitary punched-out ulcer was seen on the anterior wall of the rectum just above the level of the cervix uteri. This was obviously the source of the bleeding, for blood was oozing steadily from the ulcer. I dried the ulcer and touched the bleeding area very lightly with the diathermy point, and then held a swab soaked in Stypven on to it for some moments. A third blood transfusion was given; no more bleeding occurred. In spite of full investigations, the cause of the ulcer, which healed without further incident, was not elucidated. The possibility of pressure necrosis from the drainage tube being the cause of the ulcer did occur to me. Nevertheless, as the tube was a soft one, this hypothesis seemed unlikely.

Alarming Rectal Hæmorrhage in Unsuspected Typhoid.—*See* p. 402.

Prolapsed and Strangulated Hæmorrhoids.—A typical history is somewhat as follows:—The patient is admitted with a large mass of prolapsed internal hæmorrhoids, blue, and often bleeding. He states that for a long time the piles have come down after defæcation, but until the previous day he was able to get them back.

A hot bath is given, and the mass is washed gently, after which the patient goes to bed. The foot of the bed is raised on blocks, and $\frac{1}{6}$ gr. to $\frac{1}{3}$ gr. (10 mg. to 20 mg.) of morphine is given subcutaneously. The patient is told to lie on his back or on his side, whichever he finds more comfortable. A large quantity of gauze soaked in normal saline

solution is applied to the anus, covered with jaconet, and kept in position by an four tailed bandage. The dressing is changed every four hours. Some adrenalin be added to the saline solution in cases where œdema is considerable. Next morn

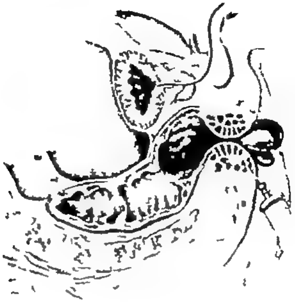


Fig. 738.—Injecting anæsthetic oil into the perianal subcutaneous tissues to relieve pain associated with strangulated internal hæmorrhoids.

patient is quite comfortable. An examination of the local conditions, as a rule, sho little change. The gauze soaks are persevered with, and liquid paraffin is order mouth. There is no need to be concerned with the movement of the bowels for th three days. If they have not ac the fourth day a gentle glycerin through a catheter is ordered, much pain follows, morphine is again. Gradually the mass gets s and by the end of a week the pi barely visible. In stubborn ca may be fourteen days before co reduction occurs. Then, after able preparation, hæmorrhoidecto undertaken.

Fig. 739.—Recent prolapsed hæmorrhoids with strangulation. The history of this patient was that three hours before admission the hæmorrhoids had come down and could not be replaced. In recent cases dilatation of the sphincter and reposition of the hæmorrhoids is a satisfactory measure.

Injection of Oil-soluble Local thetic.—A long-lasting local anæs injected into the subcutaneous of the perianal region (*Fig.* 7 sometimes of considerable value emergency measure. Great care be taken in sterilizing the skin undertaking the injection.

Mrs. W., aged 26, was in grea with massive strangulated internal hæmorrhoids of two days standing. Protocaine was in into the subcutaneous tissues of the perianal region at points 3, 6, 9, and 12 o'clock. patient had no further pain, and twelve days later hæmorrhoidectomy was performed.

Stretching the External Sphincter.—Stretching the sphincter and replacement o hæmorrhoids is a most excellent method of starting treatment, *provided the patient under observation during the first few hours* (*Fig.* 739). Local anæsthetic (1 per cent pro

[1] Proctocaine (Allen & Hanburys); Percaine in oil (Ciba); Sterijeet No. 19 (Duncan, Flo & Co.).

is injected and the sphincter is stretched gently and gradually The prolapsed hæmorrhoids are replaced, and the buttocks strapped together with broad adhesive plaster (*Fig* 760) for twenty four or forty-eight hours. If the hæmorrhoids have been out more than twelve hours, in addition to being more or less strangulated they are no doubt inflamed. Uniformly excellent results have attended the very large number of cases treated by the conservative measures outlined above. If the surgeon feels that the sphincter should be stretched in every case there is no harm done, but to go further and remove the hæmorrhoids in the acute attack, is the essence of bad surgery Œdematous hæmorrhoids are

Fig 760.— After reduction has been accomplished, the buttocks are strapped together with broad adhesive plaster

riable and the sutures cut out. Moreover the rectum cannot be prepared properly for he operation I know of two instances where fatal suppurative pylephlebitis followed he precipitate removal of strangulated piles.

Summary —Seen within a few hours after prolapse the hæmorrhoids should be replaced after cleansing them, injecting the surrounding tissues with local anæsthetic, and well oiling the parts. Do not persist in manipulations that are not quickly successful.

When pain is considerable injection of the perianal tissues with *anæsthetic oil* is a measure which is worthy of consideration

In most cases that have persisted for more than twelve hours, postural treatment and fomentations give *relief* and the prolapsed hæmorrhoids will reduce themselves gradually

Never excise strangulated hæmorrhoids in the acute stage

RECTAL PROLAPSE

The rectum should be examined for a polypus in every case

In a Child —Put the child across the knee and after well oiling the part, squeeze back the protruding membrane with finger and thumb. An anæsthetic is seldom required. It is a good practice to strap the buttock together and for the first few days, at any rate

have the child defæcate lying flat or on its side, after which the buttocks are again strapped together. Later on the after treatment is as follows:

The child is held over the chamber with the hand of the mother or nurse supporting either side of the anus with the index fingers. When the stool is passed the fingers relax and allow its passage, but during the rest of the act the index fingers press towards the anus and prevent protrusion of the mucous membrane.

Prolapse in the Aged (Sigmoido-rectal Intussusception).—*See* p. 489

Intussusception protruding from the Anus.—*See* p. 485

Imperforate Anus.—*See* p. 477

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CHAPTER XLIX

THE FEMALE GENERATIVE ORGANS

EXTRA UTERINE PREGNANCY

ALTHOUGH we are accustomed to speak of a ruptured ectopic tubal abortion is more common than tubal rupture, because the embryo is less often embedded in the isthmus of the tube than in the ampulla. Both conditions cause urgent symptoms, but of the two a tubal rupture is much the more serious.

Diagnosis.—In cases of ruptured ectopic gestation the signs of internal hæmorrhage are unmistakable. On the other hand, the diagnosis of tubal abortion is often difficult. The history of a missed period is too often lacking to be a sheet-anchor Usually the pain commences in one or other iliac fossa, and frequently radiates to the rectum referred shoulder pain should be sought in the manner described on p 368 In over half the cases there is a loss of blood from the vagina this is sometimes darker and thicker than the normal menstrual flow In most cases the cervix feels softer than usual. A tender swelling (blood) in the pouch of Douglas is seldom lacking The absence of leucocytosis is helpful in differentiating the condition from pelvic appendicitis and salpingitis.

Operative Treatment of Ruptured Ectopic Gestation.—Ruptured ectopic gestation is a most satisfactory condition to treat. Although the patient may be pulseless and absolutely blanched there is hope. Even when the condition is so advanced that anæsthesia is unnecessary it is possible to save the patient s life. In all but the earliest cases of tubal abortion blood transfusion should be arranged for as soon as possible.

It is stressed how essential it is in this emergency to verify that the blood in each fresh bottle is compatible with that of the recipient and to use only Rh-negative blood. Even so untoward transfusion reactions are more common in pregnant women than in other individuals. Therefore, commence the transfusion slowly

While awaiting the arrival of fully tested blood, plasma, dextran, or dextrose-saline solution is given intravenously according to the needs of the patient. Autotransfusion (p. 852) can be practised at the time of the operation indeed a ruptured ectopic gestation is a condition *par excellence* for autotransfusion.

The bladder should always be emptied by a catheter before commencing the operation.

The Trendelenburg Position—If the diagnosis of ruptured ectopic is even suspected, arrangements for the adoption of Trendelenburg s position should be made *before commencing the operation.* Modern operating tables are provided with shoulder rests. These should be placed in position. Strapping the legs to the table is quite a satisfactory method for maintaining the patient in a moderate degree of Trendelenburg s position. A slight tilt is all that is required. It is unnecessary and harmful to place the patient in the high Trendelenburg position, which invites the settling of blood and blood-clot in the upper abdomen.

Supplementing the Circulating Fluid—In collapsed patients it is a good practice, especially for the single-handed surgeon, to commence the operation by inserting a cannula into a vein. Dextrose-saline, dextran, plasma, or if available, blood can then be administered throughout the operation.

The Incision—In most cases a correct diagnosis can be made. *In such circumstances* the right or left paramedian incision is used. In rarer instances the diagnosis may be confused with appendicitis, when, if Battle s incision has been employed it can be prolonged down to the pubic bone and excellent access to the pelvis will be obtained. When a gridiron incision has been employed, and, by palpation, it is certain that it is a *right* ruptured ectopic prolong the incision downwards to the pubic bone by detaching the internal oblique from the rectus sheath (*see* pp. 160 161). If by inserting a finger into the pelvis soft adhesions tell that it is the left Fallopian tube that is the seat of the trouble close the gridiron incision and make a left paramedian incision. *In doubtful* cases the diagnosis is usually proclaimed as soon as the abdominal muscles have been retracted, for the blood can be seen through the peritoneum as a slate-blue discoloration.

Protection of the Skin Edges.—Within the peritoneum is a mass of blood and blood-clot, an excellent medium for bacterial growth. Asepsis should be as perfect as possible. To this end, the moment or two expended in clipping towels to the skin edges is time well spent. In this connexion it may be mentioned that appendicectomy should not be performed even if the appendix is available

The Operation—The fingers are passed into the pelvis, and the fundus of the uterus is felt. Soft adhesions and swelling of the tube will bespeak the side which is involved. No time is wasted in evacuating blood and blood-clot. As soon as the diagnosis is confirmed the table is tilted. When the desired position has been obtained, the intestines are tucked back towards the upper abdomen and packed off with a turkish towel well soaked in saline solution, so that it is heavy and does not readily become displaced. The fundus of the uterus, having been grasped by the fingers of the left hand, is tilted up towards the wound A long hæmostat is applied to the Fallopian tube near its junction with the uterus. Very gentle traction can be applied to the hæmostat while the Fallopian tube is freed. A pair of Morrant Baker forceps now encircles the tube near the ostium.

Fig. 701—Ruptured ectopic gestation Excision of the Fallopian tube Morrant Baker forceps, encircling but not crushing the tube should be noted.

The broad ligament is identified, and, using long hæmostats, the tube by clipping then cutting is detached and removed (*Fig.* 701). There now remain two or three hæmostats gripping sections of the broad ligament and one placed more medially containing the stump of the tube Each section is transfixed with a needle carrying a long tested ligature. Each ligature is tied on either side of its corresponding hæmostat. The ends of these ligatures are left long until we are satisfied that hæmostasis is perfect, when they are cut Provided the condition of the patient is good, the cut surfaces of the Fallopian tube and the broad ligament are buried as shown in *Fig* 323 p 217 so as to obviate leaving a raw area to which intestine is likely to adhere. Attention is directed to cleansing the peritoneum. Clots are scooped out with the hand. In the absence of a mechanical sucker a soup ladle or a large spoon, is a useful instrument to remove liquid blood, especially if autotransfusion is contemplated.

Autotransfusion is a very valuable measure when the patient is desperately anæmic and matched blood is not available. It should, of course, not be employed when there is any evidence of infection in the abdominal or pelvic viscera, e.g., salpingitis, and hesitancy is advisable when symptoms have been present for more than ten hours. The collected blood is citrated strained, and returned to the patient through a vein in one of the extremities.

To return to the operation instructions are given to tilt the operating table to the horizontal position slowly The towel or towels protecting the intestines are removed,

Fig 762.—Ruptured ectopic gestation. Embryo and its coverings found in the blood-clot removed.

and more blood gravitates into the pelvis and iliac fossæ; this is mopped up Unless the condition of the patient demands all the speed possible the mopping up of blood and blood-clot is done systematically The abdomen is then closed. The embryo is usually to be found in the removed blood-clot (*Fig* 762)

The patient, wrapped up well between the blankets, is returned to bed. Usually the pulse soon becomes stronger and gradually she is propped up into the sitting position. There is often a sharp rise of temperature about the second post-operative day This should not be a source of undue anxiety for the pyrexia is often transitory and due not to infection, but to the absorption of blood from the peritoneal cavity

Sometimes, during convalescence a cast of the uterus is expelled (*Fig* 763)

Fig 763.—Complete decidual cast extruded per vaginam on the fifth day after an operation for ruptured ectopic gestation.

Dangers and Difficulties.—The hazards of the operation are fortunately few —

1 *Rupture near the Uterus* —When it is the isthmus which has given way the technique should be modified somewhat The fundus of the uterus is grasped with tissue-holding forceps, which act as a tractor and serve to steady the organ A small wedge of uterine tissue which includes the origin of the Fallopian tube is removed. Mattress sutures are used to close the uterine wall.

2. *Bilateral Tubal Pregnancy* has occurred a sufficient number of times to warrant the routine examination of *both* tubes. Sometimes an unruptured hæmatosalpinx on the contralateral side is due to blood from the uterus being discharged into the Fallopian tube the ostium of which is not fully patent. It is, however unsafe

to assume this possibility In this contingency the best course is to perform salpingotomy (slitting up the Fallopian tube) on the contralateral side. Even if this Fallopian tube contains an ovum, after the products of conception have been removed it is sometimes possible to stay the hæmorrhage, and thus avoid sterilizing the patient.

3 *Adherence to Neighbouring Structures*.—In one of my cases, when adhesions had been separated, there was a raw bleeding area on the pelvic colon, presumably where the chorionic villi had taken root. The eroded area was covered in by a free omental graft. Rare cases have been reported in which perforation of the colon, rectum, or bladder has occurred from this cause, and such a possibility should be remembered.

In more advanced cases of secondary abdominal pregnancy the ideal method is to ligate as many vessels running to the gestation sac as possible, and then to remove the placenta. If the placenta does not peel off the structures to which it is adherent readily and especially if it is attached to coils of intestine or is interligamentary in position, rather than risk dangerous hæmorrhage or injury to the intestine, the correct procedure is to ligate the umbilical cord near to the placenta and to close the abdomen without drainage Ultimately the placenta is absorbed completely

4 *Rupture into the Broad Ligament*.—On rare occasions rupture of a tubal pregnancy occurs into the layers of the broad ligament. The extent of the hæmatoma varies sometimes it reaches to the retroperitoneal tissues of the iliac fossa. The first step is to remove the Fallopian tube and ligate its pedicles securely. The hæmorrhage into the broad ligament must arise from either the tubal branch of the ovarian, or the tubal branch of the uterine artery The former will have been secured during the salpingectomy just performed. The latter is in all probability also will have been ligated during the procedure, but to make certain a ligature on a needle is passed through the broad ligament to include that portion ½ in. (1 3 cm.) below the stump of the Fallopian tube This ligature, tied securely will include any branches of the uterine artery likely to have supplied the Fallopian tube (see *Fig* 773, p. 560). The hæmatoma is evacuated through a vertical incision in the posterior leaf of the broad ligament.

Fig. 764 —Tubal pregnancy without rupture. The diagnosis of acute appendicitis was made

If the operation is conducted in this way there is no renewed arterial hæmorrhage. Should oozing persist, absorbable gauze may stop it but whether it does so or not, a stab incision should be placed 1½ in. (3 8 cm.) internal to and above the anterior superior iliac spine, and a drainage tube passed extraperitoneally There is no need for haste over the removal of the tube, as it does not traverse the peritoneal cavity Antibiotic therapy is essential in these cases, for the risk of infection is high.

Tubal Pregnancy without Rupture or Abortion.—It is very exceptional and fortunate for a case of tubal pregnancy to come to operation before rupture or abortion has occurred. *Fig* 764 *shows such a specimen.* The diagnosis of acute appendicitis had been made There was, however one atypical feature in the history—*the pain began in the right side.* The tube was very mobile and salpingectomy was carried out through a gridiron incision.

RUPTURED LUTEIN CYST

Ruptured lutein cyst, or apoplectic ovary is rather uncommon. If the condition could be diagnosed with certainty operation would probably be unnecessary in the majority of instances, although in one of my cases the hæmorrhage was considerable and comparable to that of a tubal abortion. Usually the hæmorrhage is comparatively slight and seldom progressive It is the impossibility of distinguishing this condition from appendicitis that brings these patients to operation.

When, in a young woman, the diagnosis of appendicitis is probable but not certain, and operation has been decided upon, it is a good practice to open the abdomen by Battle's incision, which allows a thorough inspection of the pelvic viscera. I have found a ruptured lutein cyst on at least 20 occasions. All the patients were between 14 and 30 years of age The following is an instructive example:—

Miss C., aged 19 had had a dull pain in her right side for a week. This had not prevented her from going to work until forty-eight hours before admission, when the pain became more

evere She complained of nausea, but had not vomited. Her periods were quite regular and he last had finished eight days previously The temperature was normal and the pulse 90. On xamination, there was acute tenderness in the right iliac fossa and hyperæsthesia of the skin. 'er rectum there was fullness in the pouch of Douglas. On opening the abdomen some blood vas found. As the ovary was being delivered, a round, red ball, the size of a walnut looking like blood-clot contained in a thin membrane, slipped out of a ruptured cyst of the ovary (Fig 705). This was followed by a little dark, altered blood, and considerable fresh arterial hæmorrhage The cavity of the cyst was obliterated by a running suture, which at once controlled the hæmorrhage. About two ounces of blood clot were swabbed out of the pouch of Douglas. The appendix was removed, and the abdominal wound closed without drainage

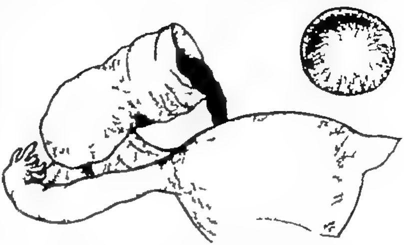

Fig 705.—Ruptured lutein cyst. From a sketch made by the author after operation upon the case cited in the text.

All that is necessary is to suture the cyst wall and mop up the blood. A running suture applied near the junction of the cyst wall and the surface of the ovary will be found to act quite well, but the suture must not be tied too tightly The tissue near the edges of the rupture is always very friable hence the base is selected for the introduction of the suture.

It is quite unnecessary to remove the ovary

TWISTED OVARIAN CYST

Provided a twisted ovarian cyst is removed before peritonitis from gangrene of the cyst has occurred, the prognosis following operation is excellent. The following example will serve to typify this rather common emergency

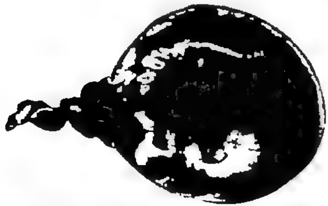

Fig 706.—Twisted ovarian cyst the size of a coco-nut removed from a woman fiv months pregnant. The pregnancy went to term.

A married woman, aged 40 whilst on the lavatory experienced intense abdominal pain and vomited. The pain continued up to the time she was examined in hospital eight hours later She had vomited three times in all during the hours that preceded her admission. The pulse was 100 and the temperature subnormal. A large, rounded, very tender swelling could be felt rising out of the pelvis. Laparotomy was performed, and an ovarian cyst the size of a foot ball, and almost black in colour presented. The pedicle had rotated several times. The pedicle was doubly ligated and the cyst removed.

The same precautions regarding the arrangements for Trendelenburg's position, and of making sure that the bladder is empty as have been described in the foregoing sections of this chapter should be taken. The abdomen is usually opened by a right paramedian incision, but in cases where the swelling is palpable on the left, the left paramedian incision should be chosen. On opening the peritoneum some blood-stained fluid may escape The operating table is now tilted to bring the pelvic organs into view The cyst (*Fig* 706) is delivered through the wound. If necessary the incision may be enlarged in order to facilitate the delivery of the intact cyst. In exceptionally large cysts it may be advisable to empty the cyst with a

and cannula as a rule it is better to enlarge the incision considerably rather than to run the risk of pseudomyxoma peritonei. The pedicle is traced down to its origin, and two long hæmostats are applied Between these the pedicle is divided (*Fig* 767). The base of the pedicle is now transfixed with a stout ligature previously tested (*Fig* 768). This is tied. It is a wise precaution to apply two ligatures to the base of the pedicle in case one should break or slip The stump should be covered by peritoneum on every possible occasion.

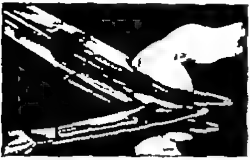

Fig. 767 —Dividing the ovarian pedicle between hæmostats.

Conservation of the Ovary in Young Women.—In cases of twisted ovarian cysts, it is not always necessary to remove the ovary. This is a consideration when the patient is young and particularly when she is possessed of one ovary only

Provided that the twisted cyst is not obviously infarcted, Stanley Way advises, and has practised successfully on a number of occasions, untwisting the pedicle When the pedicle *can* be untwisted the same principles that are used in the management of doubtfully viable intestine are invoked viz. the anæsthetist administers pure oxygen while the cyst is covered with a short relay of warm, moist packs.

In favourable circumstances (i.e. the pink colour returns to the cyst) ovarian cystectomy —enucleation of the cyst from the ovary—should be undertaken. The bleeding bed of the cyst in the ovary is repaired with sutures, and the result is often the conservation of an ovary capable of considerable function.

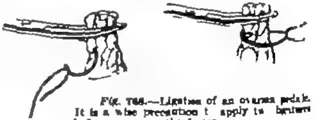

Fig. 768.—Ligation of an ovarian pedicle. It is a wise precaution to apply two ligatures before removing the forceps.

Twisting of an Ovarian Cyst during Pregnancy[1] is not uncommon. After ninety days of pregnancy the danger that removal of the ovary will result in abortion is not great. Especially before that time and when there is any indication that the corpus luteum has been removed along with the cyst, the incidence of abortion is reduced almost to vanishing point by the daily injection of 50 mg progesterone intramuscularly supplemented by the oral administration of diethylstilbœstrol for three months (Phillpot).

Fig 769 —Torsion of the Fallopian tube with a cyst of its fimbriated extremity The ovary which is also seen in the specimen, was blue and hæmorrhagic and was therefore also removed. From a girl aged 21 The principles set out in conservation of the ovary should have been practised in this case

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[1] About 50 per cent of ovarian cysts that twist are dermoid cysts. Such cysts contain enough calcium to cast an X ray shadow This can prove of considerable diagnostic assistance especially during late pregnancy

Slipping of the Ligature on an Ovarian Pedicle.—Rutherford Morison wrote "No pedicle should slip if it is tied properly. After several hundred ovariotomies the following case has been my first personal experience of such an accident. I removed a large, broad ligament, papillomatous ovarian cyst at 12.30 p.m. The operation presented no difficulty. At 6 p.m. the same day Mr Willan found the patient pallid, pulseless, and complaining of noises in the head and mistiness of vision. The abdomen was dull in both flanks. He made a diagnosis of slipped ligature with intraperitoneal hæmorrhage, and took her to the operating theatre at once. On opening the wound the abdomen was found to contain abundant clots and fluid blood, but the circulation was now so weak that some oozing only was observable. The pedicle was re-sutured and intravenous infusion carried out. Recovery ensued."

Cysts of the Fimbriated Extremity and the Hydatid of Morgagni present no special features. An example is illustrated in *Fig.* 769.

RUPTURE OF AN OVARIAN CYST

Unless it is known that the patient had an ovarian cyst before the catastrophe occurs the pre-operative diagnosis is hardly possible.

Rupture of an Ovarian Dermoid Cyst.—

A woman of 48 was admitted with diffuse peritonitis. Her symptoms had commenced very suddenly five hours previously. The whole abdomen was intensely rigid, and shifting dullness could be elicited. On a diagnosis of perforated peptic ulcer the upper abdomen was explored, but no perforation in stomach, duodenum, or gall-bladder was found. The peritoneal cavity below the umbilicus contained gruel-like fluid. A hand passed down towards the pelvis discovered a semi-collapsed ovarian cyst. The upper abdominal incision was closed and a left lower paramedian made, and through this ovariotomy was performed. The cyst, which was a dermoid of the left ovary, had a ragged tear through which its contents were escaping. The peritoneal cavity was drained suprapubically, and convalescence was uneventful.

Rupture of a Malignant Ovarian Cyst.—

A spinster of 35 was admitted in a collapsed condition. There was a history of two attacks of pain lasting about four hours during the two preceding months. The present (third attack) commenced three days previously, and the pain was located mainly in the left iliac fossa. On examination, the pulse-rate was 134 and the temperature 99·9° F. (37·7° C.). The abdomen was enormously distended, dull in both iliac fossæ and the hypogastrium, resonant around and above the umbilicus. There was no shifting dullness. Rectal examination was negative. A diagnosis of appendix abscess spreading to the left iliac fossa and leaking into the general peritoneal cavity was made, but we did not feel very confident about it. A leucocyte count was therefore done, and returned 17,200. The abdomen was opened by Battle's incision, and on incising the peritoneum quarts of jelly-like material exuded. A pailful of this material flowed out over the towels into the bucket. On passing a hand into the pelvis the collapsed shell of an ovarian cyst was felt at once. This was delivered, and its pedicle divided between forceps. The pedicle was a very thick one, so it was sewn with a running suture, instead of ligating it. Suprapubic drainage. The patient's condition improved almost as soon as the abdomen was opened, and convalescence was smooth. Four months later she returned with a large swelling of the abdomen and much emaciation. Laparotomy showed multiple secondary deposits of carcinoma over the whole of the peritoneum. Death occurred one month later.

Ruptured Chocolate Cyst.—Chocolate cysts of the ovary are always bilateral. Such cysts may be derived from the corpus luteum or from endometrial rests. Prognostically the latter are more serious. When one of these cysts bursts hæmatocolpos-like fluid extravasates into the pelvis so far as adhesions permit it, and symptoms arise which are impossible to differentiate with certainty from appendicitis or diverticulitis. I have opened the abdomen under these circumstances on a number of occasions. One may even find these chocolate cysts by accident.

Miss K. L., aged 27, gave a typical history and had signs of appendicitis of twenty-four hours' duration. On opening the abdomen an acutely inflamed retrocæcal appendix was found and removed. The appendix was later found to contain pus. There was some dark, chocolate-coloured fluid in the abdomen, and on passing a hand into the pelvis two large ovarian cysts were discovered. The right cyst was removed. With the object of conserving some ovarian tissue instead of performing oöphorectomy the left cyst was incised, and black, tarry fluid evacuated. The cyst wall was then cleaned of all contents and turned inside out after the manner of Jaboulay's operation for hydrocele. One year later the patient was in good health and menstruating regularly.

In dealing with this condition it is necessary to be most meticulous concerning mopping-up the tarry fluid, for should the condition be due to endometriosis, the cells of that tumour are liable to be disseminated. One should also palpate the uterus and note particularly if there is any adherence of it to the rectum behind or the bladder in front, and whether there is an increased bulkiness, particularly of the body. Such findings and a histological examination of the ovarian cyst are valuable in determining if further surgical treatment is advisable after reasonable convalescence. Histological examination of the material removed should never be omitted in these cases.

From time to time cases of ruptured chocolate cyst are encountered where the extravasated material is surrounded by dense adhesions. In these circumstances the proper course is to evacuate the tarry fluid and remove only that portion of the wall of the cyst that is relatively non-adherent. The subsequent course can be controlled by inducing an artificial menopause.

SUPPURATING OVARIAN CYST

Mrs. S., aged 57, had had vague abdominal pain for fourteen days. Three days previously the pain became much worse, and was situated mainly in the lower abdomen. On examination, the pulse and temperature were normal. There was general abdominal rigidity and shifting dullness. In the pelvis a large swelling could be felt. A diagnosis of (?) twisted ovarian cyst was made. On opening the abdomen frankly purulent fluid escaped. A large suppurating right ovarian cyst was removed, and the peritoneum drained suprapubically. Recovery.

On cutting into the specimen the interior of the cyst was filled with typical pseudomucin. One portion of the cyst wall was thicker than the remainder and this area was sparsely honeycombed with purulent material. The appendix was examined at operation and found to be normal.

NECROBIOSIS OF A UTERINE FIBROID GIVING RISE TO PERITONITIS

Mrs. M. C., aged 30, was twenty weeks pregnant. On the night before admission she was awakened at 3 a.m. with abdominal pain which had continued for twenty hours. The pulse was 96 and the temperature normal. The uterus extended to the umbilicus, and to the right of it a very hard tender lump could be felt. A diagnosis of ovarian cyst (?) appendix abscess, was made. She was placed in Fowler's position and an hourly pulse and temperature chart kept. During the night the pain became intense, the pulse rose steadily to 120, and she vomited. At 4.30 a.m. it was decided to operate. On opening the peritoneum some seropurulent fluid escaped. A subserous, sessile fibroid the size of a golf ball, and almost black in colour came into view. We tried to recognize the fishy odour said to accompany necrobiosis, but we were unable to detect it. After isolating the area with abdominal packs, the fibroid was surrounded by a ring of sutures passed through the muscular wall (*Fig.* 770). These were tied. An incision was then

Fig. 770.—Necrobiosis of uterine fibroid. Sutures were introduced around the base of the fibroid with a view to lessening hæmorrhage during enucleation.

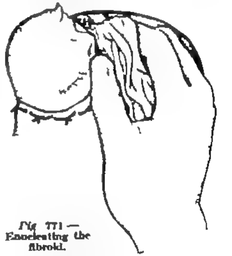

Fig. 771.—Enucleating the fibroid.

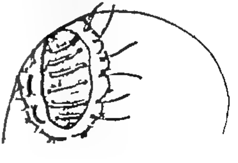

Fig. 772.—Obliterating with mattress sutures the cavity left after enucleating the fibroid.

made through the peritoneum at the base of the fibroid. By gauze dissection, aided by the handle of the scalpel and here and there by the knife, the fibroid was enucleated (*Fig* 771). It did not come away very easily and smart hæmorrhage occurred despite the ring of sutures. This was quelled temporarily by gauze pressure. The gap was then closed by a number of mattress sutures introduced on a blunt needle (*Fig* 772). Finally the peritoneum was brought over the suture line and the abdomen closed without drainage. Two days later the patient aborted, after which she made a good recovery

Using the same technique I removed a necrobiotic fibroid from a woman 6 months pregnant In this instance the pregnancy was not disturbed.

HÆMATOMETRA OF ONE HALF OF A BICORNUATE UTERUS

The patient was an Italian girl aged 20. She was having agonizing attacks of abdominal pain precisely similar to left renal colic with one exception—the pain began in the groin and passed to the loin. For four or five years there had been similar attacks, but they were getting more acute. She had been in three hospitals for renal investigation, with negative findings. Two or three hours later cystoscopy was performed. Both kidneys proved to be functioning satisfactorily A pelvic examination revealed an indefinite tender swelling on the left side of the pelvis. On opening the abdomen this was found to be due to what appeared to be a fibroid on the left side of the fundus of the uterus. The mass, which was the size of an orange was resected from the uterus the resulting cavity was closed with mattress sutures. On bisecting the specimen it was found to contain a closed cavity filled with tarry blood under great pressure. Recovery The patient has remained well and menstruates regularly

TRAUMATIC PERFORATION OF THE UTERUS

There is a definite trend towards inserting a rubber catheter into the uterus for the purpose of inducing abortion of course other objects, including the notorious knitting needle and elm bark, are still used.

Leprosky and Ostreich's case —

A woman of 33 complained of abdominal pain, and stated that she had introduced a catheter into the womb, and was unable to recover it. The temperature was 102° F (40° C.) and the pulse 80 The right lower quadrant of the abdomen was rigid and tender Vaginal examination revealed that the cervix was soft and the uterus very tender A plain radiograph showed a catheter in the pelvis. Right lower laparotomy was performed. There was a small perforation in the right posterolateral aspect of the uterine fundus with all but ½ in. (1 3 cm.) of the catheter lying free in the pouch of Douglas. The catheter was removed and the rent in the uterus repaired with catgut sutures. The case was an early one so the abdomen was closed without drainage With antibiotic therapy the patient recovered.

These authors report two similar cases, and each of these three patients had aborted before admission to hospital. In a fourth patient giving the same history the patient had not aborted. At operation the uterus was found to be intact Hysterotomy yielded a three months fœtus and a No. 16 rubber catheter In all four cases the catheter was visualized by a plain radiograph. When the uterus is perforated by a catheter the activity of the myometrium propels the foreign body through the perforation into the peritoneal cavity

Perforation of the uterine wall also occurs occasionally at the placental site during curettage after incomplete abortion, usually from using an insufficiently blunt curette.

HYSTERECTOMY

The indications for hysterectomy as an urgent measure are few—namely severe injury rupture during labour (see p 370), and occasionally for an impacted cervical fibroid

In performing urgent subtotal hysterectomy there is, as a rule no need to excise the ovaries, and usually the Fallopian tubes may remain.

Trendelenburg's position is essential. It is a mistake to be cramped for room the incision should be ample Packing off the intestines is carried out in the same manner as indicated in the section on ruptured ectopic gestation (p 332).

1 The fundus of the uterus is grasped with a vulsellum. Referring to *Fig.* 7 it will be seen that the ovarian artery lies some distance beneath the tube. Hæmostats applied to the broad ligament close to the uterus, and include the Fallopian tube and much mesometrium[1] as possible. In this way the ovarian artery is included in the bite. With scis the tissue is divided between hæmostats.

2. The round ligaments divided between hæmostats.

3. The broad ligament is further divided. This area is a cular

4 With the uterus retracte the opposite side the layers of broad ligament are opened up the finger and the uterine art are exposed at the sides of the ut near the cervix.

5 Taking care not to in the bladder a flap of peritoneu reflected off the anterior wall of body of the uterus near its junc with the cervix.

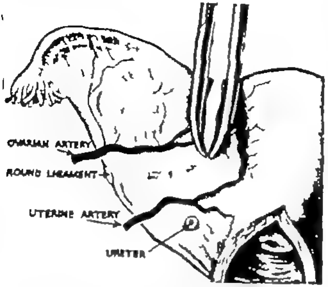

Fig 773.—The blood-supply of the uterus, with especial reference to hysterectomy (*After Bland-Sutton*)

6 The uterine arteries can seen coursing up the uterine wall or if not seen their pulsations can be felt. E artery is divided between hæmostats close to the uterus.

7 A posterior flap may be fashioned, but usually this is not necessary The operator pulls the uterus towards him and amputates the organ just above the point where the uterine vessels are clamped (*Fig* 774)

8. Each hæmostat contains an important vessel. With long well tested ligatures on a needle mounted in a holder the tissue included in the forceps is transfixed and ligated. Oozing from the stump is controlled by mattress sutures.

9 After the field has been mopped and hæmostasis is satisfactory the peritoneum is drawn together with interrupted or continuous sutures over the cervical stump.

Fig 774.—Subtotal hysterectomy The l ligaments have been divided, the uterine art clamped, and the cervix is being divided. (*Berkeley and Bonney*)

Impacted Uterine Fibroid causing Retention of Blood-stained Urine.—A farmer's wife, aged 42, was admitted from an outlying district She had never ailed until one week previously when she could not pass urine. Her doctor catheterized her and withdrew blood-stained urine. Retention continued; each day the urine became more blood-stained, until clots and debris made satisfactory catheterization impossible For 48 hours her urine had been foul smelling and her temperature elevated By the time the patient reached the hospital after her long journey the bladder was greatly distended. Decompression was arduous, be the catheter repeatedly became blocked with clot. When the bladder had been emptied, bima pelvic examination revealed a hard mass occupying the true pelvis. Lower laparotomy

[1] Mesometrium—That portion of the broad ligament below the mesovarium (B.N.A.).

performed. A uterus, as such, could not be felt, but there was a hard, smooth round mass filling the entire true pelvis, and this mass seemed to be entirely extraperitoneal. The empty bladder was œdematous and its wall felt an inch thick. The bladder was dissected forwards, a scalpel being necessary to start the dissection. A potential cleft between the bladder and the fibroid was found. Into this a finger was inserted in the endeavour to ease the impacted tumour. Venous hæmorrhage was free but after a time sufficient of the tumour was raised on the left side for a long hæmostat to grasp what later proved to be the neck of a Fallopian tube (*Fig.* 778). A similar measure was carried out on the right side. Even with the help of the traction afforded by the hæmostats, the tumour could not be prised from its bed in front. Posteriorly there was no pouch of Douglas, so, keeping close to the tumour the peritoneum was incised and a finger was used to burrow retroperitoneally behind the mass. With the house surgeon exercising steady gentle traction on the hæmostats, I was at last enabled to get sufficient purchase from behind to push the tumour out of the true pelvis. Once the process had begun, up it came with a sucking noise. Subtotal hysterectomy was then performed uneventfully. The peritoneum was closed, and at this juncture suprapubic cystostomy was performed. The abdomen was then closed, the suprapubic tube being brought out through the extreme lower end of the incision. Convalescence was uneventful.

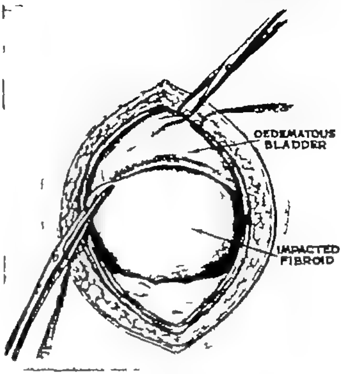

Fig. 778.—Fibroid so tightly wedged in the true pelvis that its extraction was supremely difficult.

HÆMATOCOLPOS

The recurrent attacks of pain have many times been mistaken for appendicitis. If there is a hæmatometra in addition the resulting pelvic swelling can add to the difficulties of diagnosis. Once the condition is recognized treatment is of the simplest character. An incision large enough to admit the index finger is made in the centre of the hymen, and the retained menses, in the form of tarry fluid, pour out.

The fluid should be allowed to drain away spontaneously. Instrumentation and douching should be avoided because of the risk of infecting the hæmatocolpos fluid.

PELVIC CELLULITIS

(*Syn. Parametritis*)

Infection occurs through some breach in the continuity of the vagina or cervix, or in puerperal cases, from the endometrium. Usually following delivery or operation, and about the third to fifth day, there is a sudden rise in the temperature to 103° F. (39·4° C.) or more. Quite often the patient will have few or no complaints, and the surgeon's attention is directed to the condition only by the temperature chart. In an established case bimanual examination will reveal diffuse induration. The uterus is fixed, and its limits are difficult to determine. The entire pelvic contents may feel as though fixed in cement. As a rule, the condition responds to expectant treatment in low Fowler's position and antibiotic therapy.

[1] A myoma screw, which was not available, would have proved a great help.

The indications for operation are few; the main ones being (1) That fluctuation can be elicited in the parametric mass (2) That a satisfactory response of the local condition to antibiotic therapy has not been obtained.

Operation.—Correct technique is highly important. An incision is made 1 in. (3 cm) above and parallel to the inguinal ligament, and the steps of the operation are precisely similar to those for exposure of the external iliac artery given on p. 930. The finger

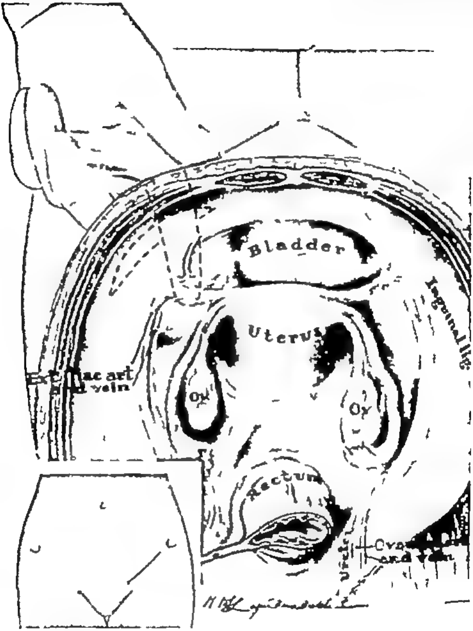

Fig 770.—Drainage of a parametric abscess. (*After Douglass and Sheldon.*)

is inserted very gently close to the wall of the bony pelvis, but crooked posteriorly pointing in a medial direction in order to avoid the external iliac vein. The mass can be felt by the finger (*Fig* 770), particularly when pressure is made with the other hand upon the lower quadrant of the abdomen of the corresponding side. By this means an abscess may be encountered. At other times a gush of semipurulent serum follows. In the latter case the discharge usually becomes more profuse in the course of a day or so, and the patient often shows considerable general improvement. The drainage material should be of the softest character—corrugated rubber tissue or a Penrose drain.

POSTERIOR COLPOTOMY

Posterior colpotomy is a good method of draining a local collection of pus in the pouch of Douglas, particularly when the abscess is connected with disease of the internal genitalia.

Preliminary Preparation.—The vulva is shaved, and the bladder is emptied by a catheter

After being anæsthetized, the patient is placed in the lithotomy position. The vulva is washed thoroughly with ether soap and warm water The interior of the vagina, including the fornices, is scrubbed with gauze over the fingers, using a soapy solution. This is followed by an ample douche of 1–1000 perchloride of mercury

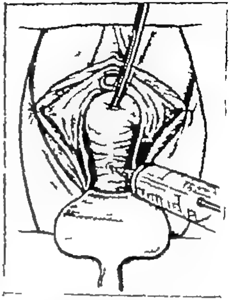

Fig. 777 —Diagnostic aspiration of the pouch of Douglas. (*After Wilfred Shaw*)

Confirmation of the Diagnosis.—If there is doubt as to the nature of the fluid in the pouch of Douglas, aspiration can be employed. The posterior vaginal wall is retracted backwards and the anterior lip of the cervix is drawn forwards and upwards. The needle is introduced as shown in *Fig* 777

The Operation.—A posterior vaginal speculum is placed in position. Auvard s self retaining weighted speculum (*Fig* 778) is very convenient, and a headlight is an advantage. The posterior lip of the cervix is grasped in a vulsellum (*Fig* 779) and pulled downwards and slightly forwards. If the posterior fornix is bulging and œdematous—in other words, if the abscess is pointing—a pair of sinus forceps may be used. The forceps, with blades closed are passed into the

Fig. 778.—Auvard self-retaining weighted speculum.

Fig. 779.—A vulsellum.

most prominent part of the swelling. The blades are then opened, and pus pours out

If the abscess is not pointing but it is thought advisable to drain by this route pull the cervix downwards and slightly forwards with the vulsellum, and make a transverse

incision through the vaginal mucosa at the junction of the posterior fornix and the cervix (*Fig* 780). This exposes the peritoneum. Proceed now with long curved scissors. As soon as the peritoneum comes clearly into view pinch it up in a long hæmostat, and make

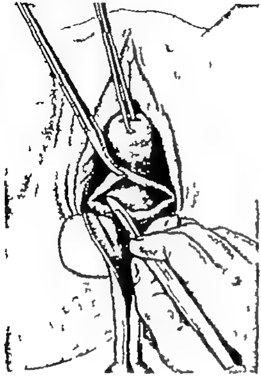

Fig. 780 —Posterior colotomy

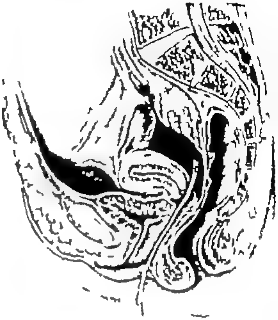

Fig. 781 —Drainage of pouch of Douglas by posterior colpotomy

a transverse nick in it. The finger is passed through this and the incision enlarged if necessary When an abscess has been opened into the vagina, a drainage tube is passed up into the abscess cavity (*Fig* 781).

Acute Salpingitis.—*See* Chapter XXIII.

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CHAPTER L

SOME EMERGENCIES IN OBSTETRIC PRACTICE REQUIRING SURGICAL MEASURES

By F R. W K Allen M.D M.A.O M.R C O G

CLASSICAL CÆSAREAN SECTION

The operation has the virtue of simplicity Although the majority of surgeons agree that the classical operation is inferior to the lower segment Cæsarean section the classical operation is performed occasionally in cases of great urgency In addition some surgeons prefer the method for cases of placenta prævia. Statistics show that the classical operation has a higher mortality and morbidity rate than the lower segment operation. Post operative shock occurs more frequently after the classical operation than after lower segment Cæsarean section. As in nearly 50 per cent of cases the placental site lies anteriorly the risk of severe hæmorrhage is greater than with the lower segment operation.

The greatest danger of the classical Cæsarean section is when the contents of the uterus are infected, for the risks of post operative peritonitis and paralytic ileus are considerably higher than those following the lower segment operation, not only from the spill at the time of the operation, but from subsequent leakage of infected material from the interior of the uterus into the peritoneal cavity Remote complications are also relatively frequent there is a risk of adhesion of intestine to the uterine scar and the scar is more liable to rupture during subsequent pregnancy or labour than the lower segment scar

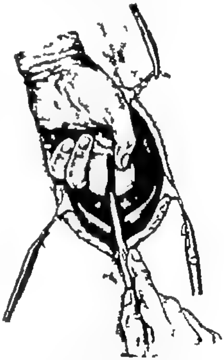

Fig. 782.—Completing the incision through the uterine wall.

Operation.—The anæsthetized patient is placed level (not in Trendelenburg's position) on the operating table In desperate circumstances, such as when the patient is exsanguinated from a placenta prævia, the operation can be performed in her bed while a blood transfusion is in progress.

A right paramedian or midline incision is made from the umbilicus to the symphysis pubis and the pregnant uterus is displaced. After correcting any dextro-rotation a horse-shoe-shaped roll of gauze wrung out in saline solution is tucked under the edges of the peritoneum from one iliac fossa to the other bowed towards the patient's head. The uterus is incised vertically in the midline for about 5 in. (12 5 cm.)

The centre of the incision is deepened cautiously to avoid wounding the baby until the uterine cavity is entered. Two fingers are inserted and the incision is completed (*Fig* 782) When the placenta is in the way (*Fig* 783) the hand displaces it rapidly A leg is sought, and the child is delivered slowly and steadily by traction the head being manipulated through the wound. While the infant is being extracted an assistant injects 0·5 mg of ergometrine and 5 units of pitocin into the uterine wall. Two hæmostats are placed upon the cord which is divided between them. The baby is handed to an assistant. The placenta and membranes are now removed Any shreds of membrane that remain are wiped off the uterine wall with a damp swab. The interior of the uterus is inspected and

palpated *for rupture*. The incision in the uterus is repaired in the following manner: four deep mattress sutures of No. 3 catgut are placed deeply through the uterine wall,

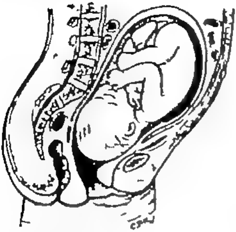

Fig. 783.—Obstructed labour with placenta on anterior wall. Note position bladder may assume.

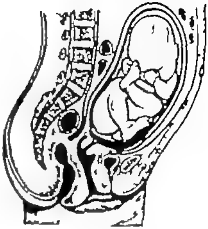

Fig. 784.—Placenta prævia.

but not through the mucous membrane. As soon as these have been tied, bleeding is under control. The more superficial portion of the incision in the uterus is coapted

Fig. 785.—A method of suturing the uterine incision. For the sake of clarity the uterus has been eventrated. In practice this is undesirable.

by a running suture of No. 2 catgut (*Fig.* 783). Abdominal packs, if any, are now removed and counted. Blood and exudate in the peritoneal cavity is mopped out and the abdomen closed. Tension sutures in the abdominal wall should not be removed for ten days.

THE LOWER SEGMENT CÆSAREAN SECTION

The lower segment operation has become a routine operation because of its following advantages —

1 The lower segment is thinner and less vascular than the body of the uterus.
2. It is quiescent after delivery hence healing is expedited.
3. The position of the incision minimizes the risk of intraperitoneal adhesions.
4. Should the wound leak the vulnerable portion of the peritoneal cavity is unlikely to be endangered.
5. There is less risk of rupture of the scar in subsequent pregnancies.
6. The child is usually born head first, which increases its chance of survival.
7 In a case of sepsis or rupture of the uterus it is comparatively easy to perform subtotal hysterectomy by extending the incision around the lower segment.

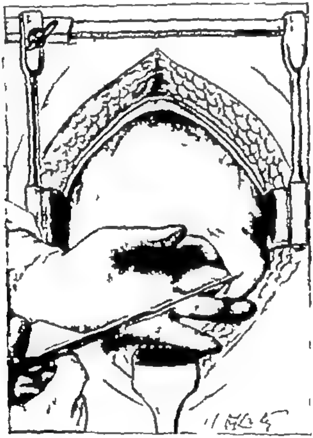

Fig. 780.—Dividing the peritoneum transversely just above the dome of the bladder

The Operation.—The bladder must be emptied by a catheter remembering that the pressure of the fœtal head tends to divide the bladder into two compartments.

The patient is positioned as for the classical operation.

A right paramedian or a midline incision is made from the umbilicus to the symphysis pubis.

Dextro-rotation of the uterus is corrected. Unless a mechanical sucker is available a horseshoe-shaped roll of gauze wrung out in saline is tucked beneath the edges of the peritoneum from one iliac fossa to the other bowed superiorly

Adequate exposure of the uterovesical pouch is essential to this end a larg [illegible] placed in the lower extremity of the wound is most helpful. The injection of [illegible] or saline solution beneath the peritoneum over the lower segment aids the follow[illegible] Immediately above the bladder a transverse incision 6 in. (15 cm.) long [illegible] convexity upward (*Fig* 780) is made in the loose peritoneum, which [illegible] segment for about 1½ in. (3·75 cm.) above the dome of the bladder [illegible]

removed from the lower extremity of the wound. The peritoneal flap is separated upwards and downwards the bladder being reflected off the lower segment by finger (*Fig* 787) and gauze dissection, pressure being directed against the uterus. By passing the fingers between the pelvic wall and the infant's head within the uterus, usually the head can be disengaged from the pelvic brim. The retractor is replaced in the lower end of the wound and will help to keep the fœtal head up and the bladder down. Before commencing the 5-in. (12 5-cm.) transverse incision in the uterine wall below the original level of the bladder reflexion, unless the uterine wall is too thin from long labour it is of considerable help to insert two traction sutures. Cautiously between these traction sutures a small transverse incision is made in the lower segment. Bonney's uterine compressor (*Fig* 788) will minimize bleeding On reaching the amniotic sac the scalpel is discarded for scissors, with which the lateral parts of the incision are completed. The retractor over the bladder is removed and if the membranes are intact (*Fig* 789) they are incised. When as a result of gentle pressure upon the fundus of the uterus the head is not delivered one (*Fig* 790) or both blades of an obstetric forceps are used to guide it. Haste may be dangerous. The head is allowed to rest on the pubis for a couple of minutes while the infant's throat is cleared of mucus and an assistant injects 0 5 mg ergometrine and 5 units pitocin into the uterine musculature The infant's body is delivered slowly. As soon as the baby is free it is placed between the mother's thighs until the placenta appears in the wound. While awaiting the expulsion of the placenta the traction sutures are used to draw forward the lower segment and bleeding vessels in the uterine wall (more numerous in the lower cut edge) are ligated. Repair of the incision in the uterus is commenced. The first deep stitch of a continuous plain No. 1 catgut suture is introduced at one corner of the incision it is tied and two further turns of the stitch are introduced before temporarily laying aside the needle and its suture When the placenta has been extruded[1] the uterine cavity is cleared of membrane and examined for a rupture Excessive bleeding from a placental site if localized is dealt with by under running bleeding points with a ligature on a needle If generalized, it is controlled by packing the uterine cavity tightly with gauze which will be removed via the vagina 6–12 hours later The deep suturing of the uterine incision is continued and completed, special care being taken to ensure that the extremities of the incision are firmly coapted. The first layer closes the deep musculature avoiding the mucous membrane the posterior wall of the uterus, and the gauze if any The second

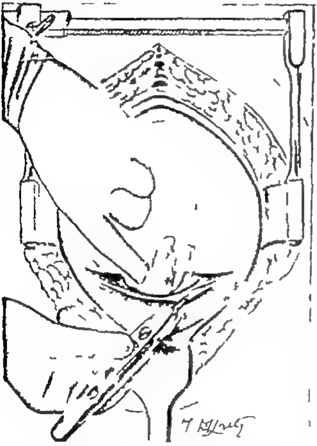

Fig 787 —A transverse incision has been made just above the bladder Using a finger and gauze dissection the peritoneal flaps are separated from the uterus.

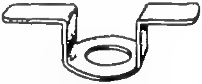

Fig 788.—Bonney's uterine compressor (*One-sixth scale.*)

[1] All authorities are agreed on the importance of slow delivery of the infant and natural separation of the placenta.

Treatment.—When faced with a uterus that is ruptured, the abdomen should be opened as soon as possible. If the fœtus be still within the uterus Cæsarean section should be performed, if convenient by extending the site of the rupture. The treatment of choice for a rupture of the uterus is subtotal hysterectomy In the unusual event of the cervix being involved in the rupture, total hysterectomy is desirable. When the anterior aspect of the lower segment is ruptured, the integrity of the bladder must always be verified In cases of traumatic rupture, conservation of the uterus by suturing the rent is rarely possible or safe, but repair of a ruptured scar from a previous operation is occasionally practicable, especially when the placenta is not situated at the site of the rupture. In a case of obvious complete rupture with extrusion of the fœtus into the peritoneal cavity and with vaginal bleeding ergometrine can be administered as an emergency measure in order to control bleeding from the rent and from the placental site while preparations for hysterectomy are being made.

REPAIR OF A COMPLETE PERINEAL TEAR

Every tear of the perineum requires repair but it may not be expedient to carry this out immediately after labour Repair of a complete perineal tear demands great technical ability and in the absence of adequate assistance it should not be attempted. Patients without infection, but too exhausted for immediate operation, are allowed to recuperate for 24 hours before repair is undertaken. When the parts are bruised or when infection has supervened, the wound is left open for drainage.

Local anæsthesia is desirable One-third of a grain (0·02 G) of omnopon is given intravenously The patient is placed in the lithotomy posture with the buttocks hanging well out over the edge of the table and the light shining into the wound. While awaiting separation of the placenta, the wound and the adjoining surfaces are cleansed thoroughly A large gauze pack, with tape attached placed in the vagina keeps the field clear of blood, but a reliable assistant must maintain a finger on the patient's pulse to watch for warning of hæmorrhage concealed by the pack.

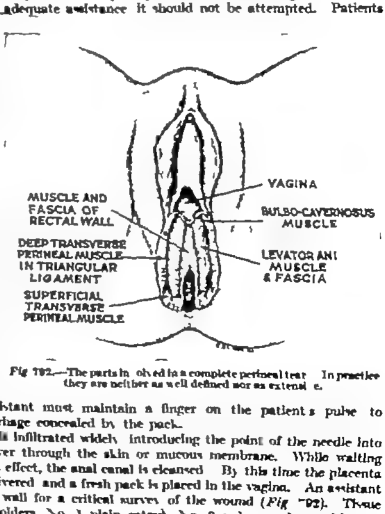

Fig 792.—The parts involved in a complete perineal tear In practice they are neither as well defined nor as extensive.

The area to be repaired is infiltrated widely introducing the point of the needle into each side of the wound—never through the skin or mucous membrane. While waiting for the anæsthetic to take full effect, the anal canal is cleansed By this time the placenta will have separated and is delivered and a fresh pack is placed in the vagina. An assistant [illegible]acts the anterior vaginal wall for a critical survey of the wound (*Fig* 792). Tissue forceps, hæmostats, needle holders, No. 1 plain catgut No 0 nylon, and round bodied curved needles will be required.

Suturing the Anal Canal.—The fascio-muscular coat and the mucous membrane are drawn together by a continuous submucous suture of No. 1 plain catgut on a round bodied curved needle commencing in the depth of the wound. The suture does *not* pass through the mucous surface into the bowel, and the knots are tied in the perineum where they will be buried. If the tear is very extensive a second reinforcing row is superimposed. Instruments are changed.

PROFOUND SHOCK DEVELOPING DURING THE THIRD STAGE OF LABOUR WITHOUT VISIBLE HÆMORRHAGE

If the patient is conscious she is given a slow intravenous injection of ⅓ gr. omnopon. A vaginal examination with full antiseptic precautions is carried out at once to ascertain whether the shock is due to a retained placenta, an acute inversion of the uterus (which can occur without anything abnormal being found either by abdominal palpation or by inspection of the vulva) or to a rupture of the uterus or other abdominal organ or blood-vessel. While this is being done or as soon as possible, an infusion of dextrose-saline or dextran is given while awaiting the arrival of plasma or matched blood.

ACUTE INVERSION OF THE UTERUS

Replacement of an Acutely Inverted Uterus must be accomplished as soon as possible. The patient is placed in Trendelenburg's position. The inverted uterus is cleansed with a mild antiseptic solution, e.g. 20 per cent dettol and a sterile towel is placed over the vulva. The patient is anæsthetized. The next step is to strip the placenta from the uterus by gauze dissection. Having made sure that the uterus has not been ruptured by this procedure the next step is :—

O'Sullivan's Method.—A vaginal or uterine douche nozzle is passed up behind the inverted uterus, and then the nozzle is attached to a sterile douch-can holding about one to two gallons and containing 20 per cent dettol or 1–1000 flavine. The can is placed 2–3 ft. (60–90 cm.) above the level of the patient. The douche is allowed to flow the operator preventing its return from the vagina by placing his hand over the vaginal outlet. The vagina will gradually become ballooned and often the uterus will revert to its normal position in a few minutes.

When this happy result does not occur within a few minutes, the operator should pass his hand into the vagina and attempt to effect reduction of the inverted uterus by taxis. This is often successful in cases of acute inversion.

Where attempts at manual reposition fail or increase shock, Huntington's operation should be undertaken without delay.

Huntington's Method.—The abdomen is opened by an incision 3 in. (7.5 cm.) long situated in the middle line above the pubes. With an Allis forceps the operator grasps one side of the surface of the uterus in the crater about 1 in. (2.5 cm.) below the rim of the inversion. Upward traction will gradually roll out the ovary, tube, and a portion of the uterus until, with a second Allis forceps, a further hold can be secured on the uterus in the crater 1 in. below the first bite. Upward traction is continued and the first forceps is removed for a third grasp in the crater. By traction and successive bites the uterus is restored to its normal position. The abdomen is closed.

In all cases antibiotic therapy is given as soon as possible, and continued as necessary.

RUPTURE OF THE UTERUS

The causes of rupture of the uterus fall into three main groups: those occurring (1) as an end result of obstructed labour, (2) as a result of injudicious operative midwifery, (3) as a result of dehiscence of a scar in the uterus. The first group arises from neglect, and is rarely seen in civilized communities. The second is an accident which may happen during decapitation or craniotomy, even in skilled hands. In addition, rupture of the uterus occurs during attempts to perform version too late in labour and by the administration of pituitary extract before delivery of the child. The third group has become relatively frequent, because incisions into the wall of the uterus are often made. The scar may be the result of Cæsarean section, or of hysterotomy undertaken during the third or fourth month. Rupture of a myomectomy scar is exceedingly rare; the scar most likely to burst during labour is that of a classical Cæsarean section.

Diagnosis.—The signs and symptoms are sudden shock, cessation of uterine contractions, and recession of the presenting part. If the fœtus is discharged from the uterus into the peritoneal cavity the fœtal parts will be felt just beneath the abdominal wall, and the retracted uterus as a mass about 6 in. (15 cm.) long separate from the fœtus. Vaginal hæmorrhage may or may not be a prominent feature.

Differential Diagnosis.—When the symptoms and signs are typical the diagnosis is straightforward. In other circumstances there may be difficulty in distinguishing the condition from pneumonia, acute cholecystitis, and particularly acute appendicitis. The urgent need is to differentiate acute appendicitis from acute pyelonephritis. The fact that the pain commenced in, and did not pass to the right side greatly favours the latter condition on the other hand, in acute appendicitis, when a retrocæcal appendix lies alongside the ureter pus, and even blood, can be present in the urine (see p. 257). Excretory pyelography may prove of great diagnostic assistance, for in early acute pyelonephritis limited to the right kidney the concentration of medium in the renal pelvis and calices on the affected side is often so poor that no shadow or a very indefinite shadow is cast.

TREATMENT OF ACUTE PYELONEPHRITIS

If the urine is acid, as is common in the coliform infections, alkalinization of the urine has a most beneficial effect in relieving the symptoms, in inhibiting the growth of these organisms, and in enhancing the bactericidal effect of sulphonamide and antibiotic therapy. To render the urine alkaline the following mixture given four hourly or more often, is efficacious.

Sodium citrate	gr 20 (1·3 G.)
Sodium bicarbonate	gr 20 (1·3 G.)
Syr aurantii	q.s.
Aqua, ad	½ oz. (15 ml.)

To diminish pain, Tinct hyoscyamus, min 20 (1·2 ml.) can be added to the mixture with advantage

In ultra-acute cases alkalinization of the urine can be brought about rapidly by an injection of 10 ml. each of an isotonic solution of sodium lactate and a saturated solution of sodium bicarbonate (see p. 03). When pain is severe pethidine 2 ml. (100 mg.) intravenously three times a day brings relief Heat applied to the loin is sometimes comforting

The patient should be instructed to imbibe large quantities of barley water and 5 per cent dextrose solution flavoured with fruit juices. In severe cases with vomiting or dehydration, intravenous dextrose-saline is given until the dehydration has been rectified and the vomiting has ceased.

While awaiting the bacteriological report in an average case a sulphonamide can be given as directed below but in a fairly severe case streptomycin or aureomycin should be substituted. When the bacteriological report is to hand, more specific treatment can be commenced if the interim measures have not proved entirely satisfactory

Chemotherapeutic and Antibiotic Agents.—

Sulphonamides Sulphatriad (a combination of sulphathiazole sulphadiazine and sulphamerazine) sulphadimidine and sulphamethiazole (urolucosil) have all proved extremely effective in the majority of cases of acute pyelonephritis. The possibility of producing sulphonamide crystalluria with any of these preparations is extremely low The dose for an adult is

Sulphatriad :

Initial dose : 1·5 G. orally given with an intravenous injection of 2 G. of the sodium salt of one of the heterocyclic derivatives of sulphanilamide (sulphadiazine sodium, for example).
First two days : 1·5 G. orally every four hours day and night (if awake).
Third and fourth days : 1·0 G. orally every four hours.
Fifth and sixth days : 1·0 G orally every six hours.

Sulphadimidine :

Initial dose : 4–6 G. orally (or in emergency 4–6 G of sulphadimidine sodium by intravenous injection).
First two days : 1·5 G. orally every four hours day and night (if awake).
Third and fourth days 0·5 G. orally every four hours, or 1 G. orally thrice daily
Fifth and sixth days : 1 G. orally thrice daily

Sulphamethiazole :

One tablet (0·1 G.) four hourly by mouth for the first two days (both by day and by night if awake). During the third and fourth days four doses are given, and on the fifth and sixth days, three doses.

Streptomycin is inimical against Gram-negative bacilli generally and has an adequate action on most staphylococci and streptococci as well. In addition to the benefits derived

from the circulation of streptomycin in the blood, 75 per cent of the drug is excreted unchanged in good concentration in the urine. L. P Garrod advises that the drug[1] should be given intramuscularly in four hourly doses of 0·5 G It is useless and dangerous to continue this treatment for more than three days usually two suffice. According to Garrod, there is good reason to believe that the issue is settled *one way or the other during* the first day

If the bacteriological reports and clinical progress so dictate either or both the above drugs are stopped immediately in favour of one of the following —

Aureomycin Longley and Thompson, of the Mayo Clinic, found that acute pyelonephritis due to either *Esch. coli* or *Aerobacter aerogenes* (the two most common infecting organisms) was controlled by small doses of aureomycin, despite the fact that the results of sensitivity tests made on the urine collected before treatment was commenced sometimes indicated the contrary

Terramycin or achromycin, 250 mg four times a day for ten days, followed by a course of sulphonamide four times a day for six weeks, has proved an excellent method of combating and eradicating the infection in all but exceptional cases (R. D Taylor)

Furadantin[2] is a synthetic antibacterial agent, one of the antimicrobial nitrofurans. It is supplied in grooved tablets containing 0·5 G Furadantin has been found effective in a number of infections due to *antibiotic resistant organisms* including *Esch. coli Proteus*, and *A. aerogenes* It is of no avail in infections due to *Pseudomonas aeruginosa.* The average dose by mouth is 3–8 mg per kilo (2 2–3 6 mg per lb) of body weight every 24 hours. One-quarter of this dose is administered immediately after meals and on retiring; cold milk should be given with the last dose at night. For refractory infections the dose may be increased to a maximum of 10 mg per kilo (4 mg per lb) of body weight per 24 hours. Accurate dosage is essential to minimize nausea and vomiting If this occurs, the dose must be reduced.

Contra indications When there is inadequate urinary output. At present it is inadvisable to employ this drug for infants and children.

Criteria of a Cure, and Investigation to reveal an Underlying Obstructive Lesion.—The duration of some form of the foregoing therapy should be continued for seven to ten days. A cure should be pronounced only when there are two or three negative urinary cultures after all traces of sulphonamide and antibiotics have disappeared from the urine. *A complete urinary tract investigation, which is usually undertaken* one week *after* the subsidence of all symptoms, must be made in all cases of acute pyelonephritis.

Chemotherapeutic and antibiotic agents usually fail to sterilize the urine in patients with abnormalities of the urinary tract. When an obstructive lesion is demonstrated by pyelography as soon as the infection has been controlled an operation to rectify the obstruction must be performed.

Proteus and Pseudomonas Infections are responsible for about 20 per cent of infections of the urinary tract, and many strains of these organisms are resistant to the drugs usually employed in the treatment of pyelonephritis.

Directly the bacteriological report is to hand and *Proteus* is reported present, the patient is best treated by the administration of furadantin. *Ps. aeruginosa* is resistant to most drugs, except polymyxin B or neomycin, which are the least desirable, because they are nephrotoxic. Polymyxin is given intramuscularly in doses of 10,000 units per kilo body weight four-hourly for five days, or longer Neomycin is the only drug that will eliminate some strains of *Ps. aeruginosa.* The dosage is 0 25 G intramuscularly every six hours for a maximum of five days. If when either of these antibiotics is being employed, the urinary output declines, the antibiotic must be stopped.

Additional Measures in Exceptional Cases

Indwelling Ureteric Catheter—A whistle-tipped catheter provides the best drainage. The eyes of the catheter must rest in the renal pelvis. If the catheter is properly in place the drainage it provides often relieves the symptoms dramatically A special nurse is desirable to watch the drainage, for if the catheter becomes blocked it is worse than useless. Gentle lavage of the renal pelvis helps to prevent blockage lavage should be carried

[1] Streptomycin is very liable to cause damage to the 8th nerve when renal function is depressed.
[2] Duncan Flockhart & Co. Ltd., Edinburgh.

out every four hours, using normal saline solution. The insertion of an indwelling ureteric catheter should only be considered in female patients, for the necessary instrumentation particularly in the presence of oliguria, is far too dangerous in the male.

Operation.—In ultra-acute cases complicated by oliguria which do not respond to the above measures, I have had a number of pleasing results by performing pyelostomy (see p. 621) or in certain cases where that measure would prove unsuitable, by nephrostomy (see p. 619) and afterwards administering continuous intravenous fluid therapy commenced cautiously. The advisability of performing pyelostomy or when that measure is unsuitable nephrostomy will now be discussed.

Indications.—When the temperature continues to reach 103°–103.5° F. (39.5°–39.8° C.) in spite of alkaline, sulphonamide or antibiotic therapy and the patient is obviously toxic, and the urinary output is low instrumentation should be eschewed. In such cases the infection has commenced in, or spread to the parenchyma of the kidney. This group will include those in which the ureter is obstructed, and those where the infection follows an operation on the urinary tract, a cystoscopic examination or urethral catheterization. A manifestly unilateral lesion should embolden the surgeon to advise an operation. The danger of waiting after conservative measures have been given a reasonable trial (two or three days) and have failed is the onset of a combination of septicæmia and anuria.

B. Bibus has found that, although usually of enormous benefit, antibiotics do not always obviate the necessity for operation in grave cases of pyelonephritis. On exposing the affected kidney in such cases extensive cortical foci are found, sometimes in connexion with perinephric suppuration. In some severe cases of acute pyelonephritis where the commencement of correct treatment has been delayed on account of difficulty in diagnosis or failure to ascertain the bacteriology of the urine antibiotic therapy at times creates a false sense of security. There is a fall in the high temperature, and a diminution of the number of leucocytes, but, in spite of adequate doses of the antibiotic indicated, the general condition gradually worsens sometimes the cachexia of patients with advanced malignant disease is simulated. Deterioration of the general condition can be prevented only by timely operation.

PYELONEPHRITIS OF PREGNANCY

If the patient is placed in the knee-chest position pressure upon the ureters is removed, and often temporary relief obtained. When postural treatment, together with alkalinization of the urine and sulphonamide, with or without antibiotic therapy is not effective catheterization of the ureter or ureters is often beneficial. It is quite common for 10–30 ml. of residual urine to be evacuated from the renal pelvis, with immediate relief. Should improvement be but temporary there is no objection to repeating the catheterization in three or four days.

When the condition is bilateral and particularly when it occurs in the early months of pregnancy the prognosis is grave. In these circumstances, if the blood-urea is elevated considerably the wisest course may be to terminate the pregnancy.

ACUTE PYELONEPHRITIS IN INFANTS

Probably the peak incidence of urinary infections occurs under the age of 2 years, when the two sexes are affected equally. At this time of life the diagnosis is sometimes particularly difficult. For instance in severe infections the accompanying bacteræmia gives rise to a hectic temperature apathy and limpness, with occasional twitching or even a convulsion; unless the correct diagnosis is made early and appropriate treatment is commenced forthwith, the patient frequently goes downhill rapidly and often dies as a result of multiple renal abscesses. Should recovery occur in these circumstances, the kidneys are so scarred that frequently the patient develops hypertension and renal insufficiency. At other times the affected infant is pale restless, vomits frequently, refuses food and has a high temperature alternatively one encounters a fat flushed feverish, restless, and whimpering baby. Typically the attack commences with rigors, and attacks of screaming due to ureteric colic occur slight terminal hæmaturia is sometimes present. In some cases a clue to the origin of the infection is apparent. In females vulvitis extends around the external urinary meatus. In circumcised males there is atresia meati with or without meatitis, while in the uncircumcised balanitis may be present. However in the majority of cases the infection is blood borne and these signs are absent.

Even when there is only a remote possibility that the symptoms are due to pyelonephritis, it is necessary to examine the urine clinically and bacteriologically. Some ingenuity is required to collect a specimen of urine from an infant. Attachment of a test tube to the penis, so long as there is sufficient space around the penis to allow the escape of air, is the best method. The female infant presents a more difficult problem. To place the baby on warmed sandbags with a shallow dish between them is the most practical. Catheterization should be avoided if possible but, when considered necessary in the female, the urinary meatus must be cleansed thoroughly before the catheter is passed. The bedside and laboratory confirmation of the diagnosis of pyelonephritis from an examination of the urine differs in no respect from that in an adult.

Treatment.—The urine should be rendered and kept alkaline with a mixture of sodium bicarbonate and potassium citrate in equal parts, 5–10 gr. (0·3–0·6 G.) with each dose of sulphonamide. Sulphatriad or sulphadimidine 0·25 G. 8-hourly for an infant under 3 months of age, and 6-hourly for one between 3 months and 2 years of age, with plenty of dextrose solution by mouth, is usually eminently satisfactory, provided of course there is no obstruction in any part of the urinary tract. When the sensitivity tests and lack of progress so indicate, a suitable antibiotic is given in addition. Deepening toxæmia, drowsiness, oliguria, persistent vomiting and possibly œdema of the face, together with casts of pus cells and erythrocytes in the urine, are clear indications of advanced renal parenchymal involvement. In such cases one of the tetracyclines intravenously, 10–20 mg. per kilo of body weight daily for five days, is the best means of combating this very serious infection. In infancy the infecting organism in a very high percentage of cases is *Esch. coli* or, much less frequently, a staphylococcus which may be penicillin-resistant.

Complications.—

Secondary Meningitis.—Twitchings or convulsions due to cerebral irritation are not infrequent, and are usually due to the accompanying toxæmia. However, if the anterior fontanelle shows increased tension, secondary meningitis must be excluded by lumbar puncture.

Diarrhœa or Vomiting is liable to appear at any time during an acute urinary infection. Special care must be taken to fulfil the fluid requirements, otherwise oliguria will exacerbate the pyelonephritis.

Oral Sepsis, including thrush, often supervenes when the general care, including oral hygiene, is inadequate.

Fatty Degeneration of the Liver, as evinced by an enlarging liver with, possibly, a tinge of jaundice, is more apt to occur when the fluid and dextrose intake has been insufficient. It adds greatly to the danger of suppression of urine.

Hæmaturia occurring during the course of the disease should always arouse a suspicion of sulphonamide crystalluria, and the urine must be examined for sulphonamide crystals.

Acute Osteomyelitis and Pericarditis must be kept in mind as possible complications when *Staphylococcus aureus* is the cause of the urinary infection.

ACUTE PYELONEPHRITIS WITH RETENTION OF BLADDER URINE

The retention of urine can arise from pre-existing obstruction of the lower urinary tract, spinal injury or disease, or be a complication of an operation (post-operative retention). The retention is not necessarily complete and the patient may be able to urinate, but there is a varying amount of residual urine, from a few ounces to several pints. In a great majority of cases the pyelonephritis is bilateral. Occasionally the condition arises spontaneously, but as a rule it follows the passage of a catheter or other instrument per urethram, which need not necessarily have been passed without every sterile precaution; lighting up of infection lying dormant in a pool of the residual urine or of chronic prostatitis can conceivably give rise to this condition. Proof as to whether organisms were introduced at the time of instrumentation is nearly always a matter for conjecture. In the days of unsterile catheterization this condition, known as 'surgical kidneys', was frequent and dreaded. Recent careful analysis of hospital records has shown that the proportion of cases of acute pyelonephritis in which the infection was probably acquired in hospital is much higher than is believed generally.

Diagnosis.—In the comparatively hale the symptoms are often severe, but they do not differ from those of acute pyelonephritis described already. Usually there is rigidity

and tenderness in both loins, though often more in evidence on one side than the other. Depending on the amount of back pressure effects upon the kidneys, a varying degree of renal failure is likely to develop.

Often in the old and frail the symptoms and signs are misleading and the only indications that acute pyelonephritis has set in are lassitude and deepening coma.

Treatment does not differ from that of acute pyelonephritis given already except that it is essential to empty the bladder and keep it empty usually by means of an indwelling catheter (see Chapter LVI). The infection is frequently due to an organism resistant to the more usual antibiotics. Although it requires much judgement as to when to perform it, and considerable courage, a swift bilateral operation to drain infected kidneys that are probably or certainly hydronephrotic sometimes offers the greatest or even the only hope of saving the life of the patient.

PYONEPHROSIS

Pyonephrosis is not, as a rule, a very urgent condition, by which is meant that a few hours can be spent in observing the patient and making as full an investigation as circumstances permit. Nevertheless nephrostomy should be performed as soon as the diagnosis can be established. Excretory urography and cystoscopy after an intravenous injection of indigocarmine will help in arriving at a correct diagnosis. Those cases of pyonephrosis that are operated upon during the first few days usually recover, whilst those in which the treatment is delayed (usually because of difficulty in diagnosis) frequently die in spite of operation. In nearly all cases it is simple nephrostomy and not nephrectomy which should be performed in the first instance. A drainage tube is inserted into the centre of the pus sac through the convex border of the kidney towards the lower pole. A soft rubber drain is also inserted into the perirenal space. Unless the cause of the obstruction can be removed at the time of the operation—e.g., a stone dislodged from the pelvis of the kidney or the commencement of the ureter—further operation will be necessary later on, otherwise the pyonephrosis will recur or permanent renal fistula result. One of my patients, in whom nephrectomy was contra-indicated on account of enormous obesity and mitral stenosis, returned three times at intervals of about six months with a recurrent pyonephrosis which was drained in each instance. Further details of the operation of nephrostomy are given on page 610.

PERINEPHRIC ABSCESS

The term perinephric abscess probably embraces a number of different conditions in which the abscess is but an important incident. There is, however, a clinical entity, perinephric abscess. Here the perinephric fat appears to be primarily attacked by a blood borne infection. Bacteriological examination of pus from the abscess frequently shows *Staphylococcus aureus*.

An ordinary examination of the urine usually reveals no abnormality, but if the last 30 ml of voided urine be collected in the male, and a catheter specimen taken from the female, Gram positive cocci are often found after prolonged centrifugalization.

The early diagnosis of perinephric abscess is difficult. In 43 cases the diagnosis was not made for (on an average) five weeks (Habein). Some improvement on these figures can be hoped for by the use of radiographic studies. Absence of the psoas shadow is inconstant, and not confined to cases of perinephric abscess. A more reliable radiological sign is what is known as the sign of Mathé. The normal excursion of a kidney between the Trendelenburg and vertical positions is not less than the width of one vertebra. This can be shown by excretion pyelography. Even in early cases of perinephric abscess these excursions are limited.

Another method of making an early diagnosis of perinephric abscess is by means of a lateral retrograde pyelogram which frequently reveals a displacement of the kidney. The typical radiological finding is displacement forward, producing a characteristic arch-like appearance of the kidney and ureter (J. G. Menville). The only specific X-ray indication of a perinephric abscess is extravasation of contrast media into the perirenal region as displayed on intravenous or retrograde pyelography (R. S. Hotchkiss).

In any case *one should not wait for fluctuation but explore as soon as the condition is strongly suspected.* If there is a fluctuating swelling, an incision and the insertion of a tube is all that is required. It is, however, a good practice to examine the kidney at the

same time Sometimes a renal carbuncle which has burst through the renal capsule is found. In one of my cases there was merely a shell of kidney substance containing caseous matter so nephrectomy was performed but this is most exceptional.

When the pus is not near the surface the abscess is approached by the usual incision to expose the kidney

CARBUNCLE OF THE KIDNEY

Often the diagnosis of renal carbuncle (*Fig* 793) is even more difficult than that of perinephric abscess, for which the condition is frequently mistaken and with which it is occasionally associated. More often than in other staphylococcal bacteremias, a portal of entry is to be found in the form of a purulent skin lesion or an abscess, e.g an abscess of the breast As in perinephric abscess, the leading feature is pyrexia. By a process of elimination and signs of tenderness in one loin an inflammatory lesion of the kidney itself is suspected. Excretory pyelography usually merely demonstrates that the diseased kidney is functioning poorly on occasions obliteration of a calix or calices adds strength to the diagnosis. Curiously pyuria is seldom in evidence although in some instances staphylococci are found in the urine from the affected kidney thus the lesion is differentiated from severe pyelonephritis.

Fig 793.—Carbuncle of the kidney (*J. L. Dick*.)

Treatment.—There is seldom need to perform nephrectomy in this condition partial nephrectomy is never required Some early cases respond quickly to systemic antibiotic therapy and the infection is aborted, but one can never be sure of the diagnosis unless the lesion is exposed by operation. When the response to antibiotic treatment is not dramatic exploration of the kidney should be carried out. T F Rose recommends making an incision into the carbuncle and scooping out the necrotic material with the finger Hemorrhage, which usually is not excessive can be controlled by the application of pressure over a moist warm pack. A drainage tube is placed down to, but not into, the resulting cavity in the kidney Penicillin or if the staphylococcus is penicillin-resistant (*Fig* 794) another antibiotic is continued for at least ten days.

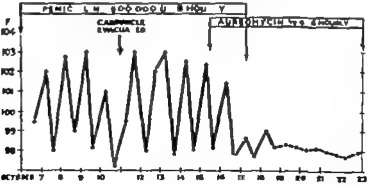

Fig 794.—Temperature chart of a case of renal carbuncle due t a penicillin-resistant staphylococcus T F Rose)

The only cases in which nep ... is to be required are those that are delayed unduly usu ... in the hope t ... on can be avoided by persisting with antibiotics.

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When the pus is not near the surface the abscess is approached by the usual incision to expose the kidney.

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Fig. 793.—Carbuncle of the kidney. (T. L. Dirk.)

Treatment.—There is seldom need to perform nephrectomy in this condition; partial nephrectomy is never required. Some early cases respond quickly to systemic antibiotic therapy, and the infection is aborted, but one can never be sure of the diagnosis unless the lesion is exposed by operation. When the response to antibiotic treatment is not dramatic, exploration of the kidney should be carried out. T. F. Rose recommends making an incision into the carbuncle and scooping out the necrotic material with the finger. Hæmorrhage, which usually is not excessive, can be controlled by the application of pressure over a moist warm pack. A drainage tube is placed down to, but not into, the resulting cavity in the kidney. Penicillin, or if the staphylococcus is penicillin resistant (*Fig. 794*), another antibiotic, is continued for at least ten days.

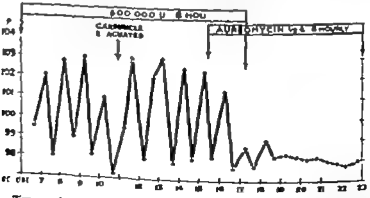

Fig. 794.—Temperature chart of a case of renal carbuncle due to a penicillin-resistant staphylococcus. (*After T. F. Rose.*)

The only cases in which nephrectomy is likely to be required are those that are delayed unduly, usually in the hope that operation can be avoided by persisting with antibiotics.

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CHAPTER LII

INJURIES TO THE KIDNEY AND URETER

RENAL injuries can be divided into slight severe and critical.

Slight injuries comprise those where the parenchyma is damaged without rupture of the capsule or extension of the laceration into the renal pelvis or a calix. (*Fig* 705 A, B.)

Severe injuries are those where the capsule is broken and/or disruption into the renal pelvis or calices has occurred. (*Fig* 705 C, D E.)

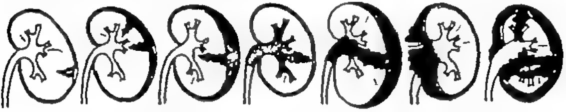

Fig 705.—Various types of renal injuries A, Small subcapsular hæmorrhage; B Large subcapsular hæmorrhage C, Cortical laceration with perinephric hæmatoma D Medullary laceration with bleeding into the renal pelvis E, Complete rupture F Avulsion of the pedicle G Fragmentation.

An injury is termed critical when the vessels of the renal pedicle are torn or the kidney is shattered. (*Fig* 705 F G.) As a result of a study of 71 cases C. A. Hodges et al. found that the distribution was as follows —

Slight	66 per cent
Severe	32 „ „
Critical	2 „ „

The injuries to a kidney incurred in civil life are very seldom the result of an open wound. Blows or falls on the loin are the most fruitful sources of such injuries, while blows from in front crushing accidents, and falls on the buttocks or feet add their quota (*Fig* 706). The injury is nearly always extraperitoneal In 108 cases I reviewed all were extraperitoneal In children below the age of 10, in whom there is little if any perinephric fat, very occasionally the peritoneum is torn in addition to the renal

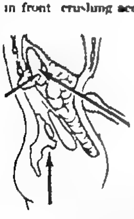

Fig 706.—With a blow from behind, the kidney is thrown against the liver With a blow from in front, it is liable to be impinged against the 12th rib. As a result of a fall on the buttocks, the vascular pedicle may be damaged. (*After F Papin.*)

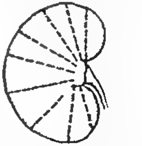

Fig 707.—Diagram to show the usual lines of rupture of the kidney

capsule allowing blood and perhaps urine to escape into the peritoneal cavity Tears the renal parenchyma follow the lines of the uriniferous tubules (*Fig* 707). One pole —early always the lower may be wholly or partially detached, always along one of the aforesaid lines (*Fig* 708).

Clinical Features.—

The sex incidence is truly remarkable. In all large series of cases males predominate in a proportion of nearly 10 to 1 It is difficult to believe that so great a discrepancy can be accounted for solely by the more strenuous life of the male Contributory factors that lessen the liability of females to renal injury are greater renal mobility in females, and the wearing of corsets.

In all large series the incidence of renal injuries is somewhat greater on the left side

Hæmaturia the cardinal sign of a traumatized kidney is present to a lesser or greater degree in over 99 per cent of cases nevertheless, frequently it does not make its first appearance until some hours after the accident, the urine voided soon after the accident being clear Rarely macroscopic hæmaturia ceases within a few hours; this, of course is likely to occur when the injury is trivial nevertheless one must not jump to this conclusion for cessation of hæmaturia occurs also when the ureter becomes occluded by blood-clot.

Fig. 798.—Ruptured kidney from a run-over accident

Clot passing down the ureter occasionally gives rise to clot-colic which is not as severe as the colic produced by a calculus. Hæmaturia is entirely absent in renal injuries only when the renal pelvis is avulsed from its ureter

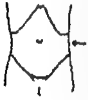

Fig 799

Shock.—A variable degree of shock is present in all but very slight injuries. When shock is profound and fails to respond quickly to treatment, if there is no other more obvious injury to account for it a concomitant intra-abdominal lesion should be suspected, and the commonest dual lesion is rupture of the spleen and the left kidney

Rigidity of the anterior abdominal wall on the affected side is present constantly in cases of even moderate severity

Local tenderness is rarely absent

A perinephric hæmatoma should be suspected if there is even a slight flattening of the normal contour of the loin (*Fig* 799) Rarely is abdominal relaxation sufficient to permit accurate palpation of the renal region, although when perirenal bleeding is extensive a mass can be felt in spite of the overlying rigidity

Meteorism.—In many cases of renal injury abdominal distension comes on within 36 hours of the accident. On several occasions I have verified that it is ballooned colon as opposed to small intestine that gives rise to this diagnostically confusing distension.

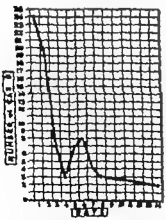

Fig. 800.—Graph showing the duration of hæmaturia in cases treated expectantly

MANAGEMENT AND TREATMENT

Even when there are no general or local signs, every patient with hæmaturia (*Fig* 800) following an accident should be put to bed and kept there for at least a week after bleeding has ceased and pyelographic studies reveal no gross abnormality The reason for this precaution is that secondary hæmorrhage into the bladder is fairly frequent and is most common during the second and third week after injury It is not unusual for this late hæmorrhage to be severe. Most cases can be forestalled if retrograde pyelographic studies of the injured kidney are made

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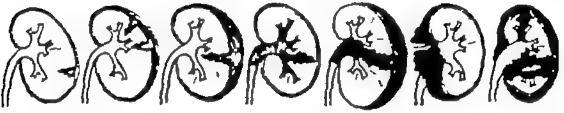

Fig. 795. Various types of renal injuries. A, Small subcapsular haemorrhage; B, Large subcapsular haemorrhage; C, Cortical laceration with perinephric haematoma; D, Medullary laceration with bleeding into the renal pelvis; E, Complete rupture; F, Avulsion of the pedicle; G, Fragmentation.

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Critical	2 " "

The injuries to a kidney incurred in civil life are very seldom the result of an open wound. Blows or falls on the loin are the most fruitful sources of such injuries, while blows from in front, crushing accidents, and falls on the buttocks or feet add their quota (*Fig.* 796). The injury is nearly always extraperitoneal. In 108 cases I reviewed, all were extraperitoneal. In children below the age of 10, in whom there is little if any perinephric fat, very occasionally the peritoneum is torn in addition to the renal capsule, allowing blood and perhaps urine to escape into the peritoneal cavity. Tears of the renal parenchyma follow the lines of the uriniferous tubules (*Fig.* 797). One pole, nearly always the lower, may be wholly or partially detached, always along one of the aforesaid lines (*Fig.* 798).

Fig. 796. With a blow from behind, the kidney is thrown against the liver. With a blow from in front it is liable to be impinged against the 12th rib. As a result of a fall on the buttocks, the vascular pedicle may be damaged. (*After P. Papin.*)

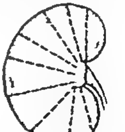

Fig. 797.—Diagram to show the usual lines of rupture of the kidney.

Clinical Features.—

The sex incidence is truly remarkable. In all large series of cases males predominate in a proportion of nearly 10 to 1 It is difficult to believe that so great a discrepancy can be accounted for solely by the more strenuous life of the male Contributory factors that lessen the liability of females to renal injury are greater renal mobility in females, and the wearing of corsets.

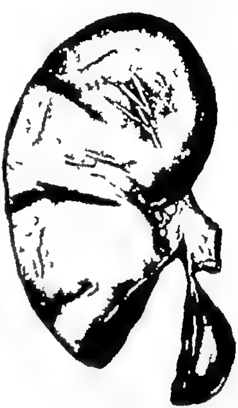

Fig 798 —Ruptured kidney from a run-over accident.

In all large series the incidence of renal injuries is somewhat greater on the left side.

Hæmaturia the cardinal sign of a traumatized kidney is present to a lesser or greater degree in over 99 per cent of cases nevertheless, frequently it does not make its first appearance until some hours after the accident, the urine voided soon after the accident being clear Rarely macroscopic hæmaturia ceases within a few hours this of course is likely to occur when the injury is trivial nevertheless one must not jump to this conclusion for cessation of hæmaturia occurs also when the ureter becomes occluded by blood-clot.

Clot passing down the ureter occasionally gives rise to clot-colic, which is not as severe as the colic produced by a calculus. Hæmaturia is entirely absent in renal injuries only when the renal pelvis is avulsed from its ureter

Fig 799

Shock —A variable degree of shock is present in all but very slight injuries. When shock is profound and fails to respond quickly to treatment, if there is no other more obvious injury to account for it, a concomitant intra-abdominal lesion should be suspected and the commonest dual lesion is rupture of the spleen and the left kidney

Rigidity of the anterior abdominal wall on the affected side is present constantly in cases of even moderate severity

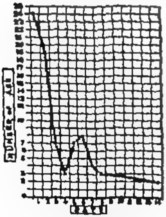

Fig. 800 —Graph showing the duration of hæmaturia in cases treated expectantly

Local tenderness is rarely absent.

A perinephric hæmatoma should be suspected if there is even a slight flattening of the normal contour of the loin (*Fig* 799) Rarely is abdominal relaxation sufficient to permit accurate palpation of the renal region, although when perirenal bleeding is extensive a mass can be felt in spite of the overlying rigidity

Meteorism —In many cases of renal injury abdominal distension comes on within 30 hours of the accident. On several occasions I have verified that it is ballooned colon, as opposed to small intestine that gives rise to this diagnostically confusing distension.

MANAGEMENT AND TREATMENT

Even when there are no general or local signs, every patient with hæmaturia (*Fig* 800) following an accident should be put to bed and kept there for at least a week after bleeding has ceased and pyelographic studies reveal no gross abnormality The reason for this precaution is that secondary hæmorrhage into the bladder is fairly frequent and is most common during the second and third week after injury It is not unusual for this late hæmorrhage to be severe Most cases can be forestalled if retrograde pyelographic studies of the injured kidney are made

To prevent infection penicillin is administered intramuscularly and sulphatriad with an alkaline mixture is given by mouth.

Treatment of Shock, if present, is commenced as soon as possible and in shocked patients frequent re-examinations are required to exclude a concomitant intraperitoneal lesion

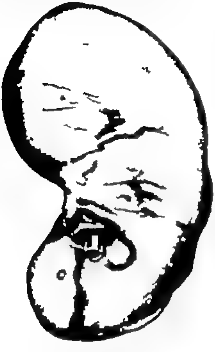

Fig 801 —*Ruptured kidney following a kick from a horse—anæmic infarction of lower pole*

Blood Transfusion.—It is advisable to have all patients with a renal injury grouped in readiness for blood transfusion. Hæmoglobin estimations and red-cell counts are made and repeated as necessary These tests are valuable in assessing the need for transfusion and the amount of blood required, except during the first few hours after admission when, on account of the unreliability of these tests at this time (see p 43), the necessity for blood transfusion must be adjudicated entirely on clinical grounds.

Recording the Pulse-rate.—When a patient with hæmaturia following an accident is admitted the pulse-rate should be recorded hourly In cases that respond to expectant treatment the frequent pulse-reading and watchful care must be continued over a longer period than the patient's general condition would seem to justify for signs of extensive laceration may be delayed Sometimes the pulse is an unreliable indicator

A youth was kicked in the right loin by a horse. On admission, pulse 80, temperature 97·6 F (36·3° C.). There was no sign of external injury or swelling in the loin. Considerable tenderness of right side of abdomen was present, also rigidity of upper right rectus. The urine contained blood. Slight hæmaturia continued for five days. During this time the rigidity persisted and the patient complained of pain in the right side Pulse remained full and unaccelerated. Suddenly at 1.30 p.m. on the sixth day there was a torrential hæmaturia. The lad became collapsed. After morphine and posture had improved the general condition, a lacerated kidney was extirpated (*Fig* 801). Recovery

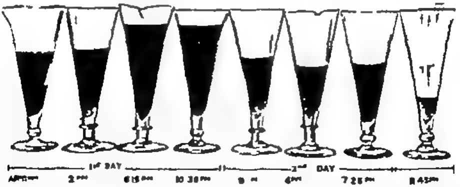

Fig 802.—Injury to the kidney The urine is saved and placed in glasses labelled with the time of passing In this way one sample of urine may be compared with a later specimen, and an estimation can be formed as to whether the bleeding is progressive or not. In this case the hæmorrhage which was at first severe abated after thirty-four hours, and the patient recovered with expectant treatment.

In spite of the fortunate outcome this case exemplifies the dictum that no patient with an injury of a kidney in whom pain and rigidity persist for 48 hours should be treated expectantly In this case an earlier operation would probably have permitted partial nephrectomy to have been undertaken.

Saving Specimens of Urine for Inspection.—In all cases the urine should be saved and placed *in glasses bearing a label indicating the time of voiding* It is then possible to compare one sample of urine with a later specimen and thus to estimate whether the external bleeding is progressive or not (*Fig* 802). In comparing two samples—especially

in an artificial light—it is sometimes helpful to dip a strip of white blotting paper into each specimen after stirring. For purposes of comparison the concentration of blood in the urine is seen more readily in the absorbent paper. The presence of clots in one sample would, of course, vitiate the result.

General Rest.—Once a diagnosis of rupture of a kidney has been made, morphine is administered, and repeated as necessary. The patient is permitted to lie in the position he finds most comfortable.

Forestalling Meteorism.—Although the distension is originally colonic, in severe cases it is a wise precaution to pass a gastric aspiration tube and to keep it in position as long as the amount withdrawn justifies its retention.

Radiography.—

A Plain Radiograph of the abdomen is always worth while, for when a kidney is injured the film sometimes reveals one or more of the following abnormalities:—

1. Slight protective scoliosis—concavity towards the side of the lesion.
2. Obliteration of the psoas shadow.
3. Loss of the kidney outline.
4. Injury to the bony skeleton, usually the 12th rib or an upper lumbar transverse process or processes.
5. Meteorism, more pronounced on the side of the lesion.

Excretory Urography (*Fig.* 603).—When facilities exist, the sooner excretory urography[1] can be carried out after the patient has recovered from shock the better. Comparatively little attention should be paid to excretory pyelographic appearances on the injured side, for they are often misleading. Blood and blood-clot in the renal pelvis is liable to prevent clear delineation; the excretion of the medium is often delayed or absent, which is in keeping with what might be expected. In one case the comparatively normal pyelographic picture vitiated my clinical judgement.

Fig. 603.—Excretory urography showing (1) scoliosis, (2) loss of right renal outline, (3) normal left kidney. (*D. E. Truscott.*)

Twenty-four hours after a street accident, although profuse initial haematuria had lessened, a middle-aged woman remained exceedingly tender in the right loin and some degree of meteorism was present. As blood transfusion had rendered her general condition tolerably good, it was decided that operation should be performed later in the day. In the interval excretory pyelography was carried out. Both kidneys were visualized, although on the injured side the outline was a little bizarre. Operation was cancelled because of the relatively normal pyelographic appearance. Four days later her condition deteriorated, and in spite of resuscitative measures, she expired during the night. Abdominal distension had become immense. Necropsy showed what might have been a reparable lesion of the parenchyma, with widespread retroperitoneal extravasation of blood and urine.

Emphatically, we should rely not on excretory pyelographic appearances, but on clinical signs aided when in doubt by *retrograde* pyelography, to decide whether to explore or to continue conservative treatment. The value of excretory pyelography in injury to a kidney lies in the demonstration of a functioning contralateral organ, for the concrete proof of which the surgeon should be truly thankful.

[1] With the newer compounds such as hypaque (Bayer Products Ltd., Kingston-on-Thames, Surrey) it is best to undertake excretory urography with the patient's body tilted at 10° by the head. When undertaking urography for suspected renal injury in no circumstances must compression be used, as is usual in non-traumatic cases.

Retrograde Pyelography.—Many surgeons are prejudiced against retrograde pyelography. They believe that injection of the contrast medium will incite renewed bleeding, irritate the ruptured parenchyma, and disseminate infection. There is no evidence to support any of these contentions. Provided the patient is in excellent general condition and the surgeon is an experienced cystoscopist, retrograde pyelography should be performed in all cases where the advisability of operation is not evident on clinical grounds. Only retrograde pyelography can delineate accurately the extent of the injury and provide evidence that will enable the surgeon to forestall catastrophes such as have been exemplified by the two cases quoted. Concomitant administration of antibiotic and chemotherapeutic agents, together with aseptic cystoscopy and the use of modern non-irritating contrast media, render retrograde pyelography quite safe. However, if by retrograde pyelography a rupture is demonstrated, one should be prepared to explore the kidney without delay lest renewed serious hæmorrhage recommences as a result of the examination.

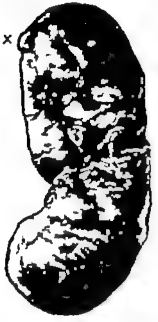

Fig. 801.—The specimen taken from the patient referred to in the text. The kidney was practically avulsed except for vessels entering the upper part of the pedicle (X).

The Diagnosis of Ruptured Kidney has been made, but is there an Intraperitoneal Lesion also?—

When the surgeon is unable to exclude an intraperitoneal lesion indubitably he should explore the abdomen. For this purpose a midline incision immediately above the umbilicus, just large enough to allow the hand to be inserted, is sufficient. *Having ascertained that there is not an undue amount of free* fluid in the peritoneal cavity and having verified the presence of a bulging hæmatoma in one loin and a normal kidney in the other, much the best course is to close the laparotomy incision and expose the kidney from the back. Abdominal nephrectomy in the presence of even moderate meteorism is a Herculean task.

A well-developed youth was knocked off his bicycle. He arrived in hospital in a shocked condition complaining of severe left-sided abdominal pain. The first specimen of urine was full of bright-red blood, but subsequently he passed almost clear urine several times. During the night his pulse-rate rose from 90 to 123. It was at this time that I was called to see him. He was obviously anæmic. The abdomen was distended and shifting dullness could be elicited. As soon as practicable the abdomen was opened through a limited midline upper abdominal incision. Serous blood-stained fluid ran out. The spleen and liver were intact; the palpating hand readily made out a large retroperitoneal hæmatoma on the left side. The right kidney was present. The abdominal incision was speedily closed. Turning the patient over, the left kidney, surrounded by blood-clot, blood, and urine, was exposed. The renal pelvis was torn across almost completely; indeed, the kidney was practically avulsed from its pedicle. Nephrectomy was performed (*Fig.* 801). The perirenal space was packed firmly with dry gauze. Suturing the wound was omitted save for the skin stitches. The patient was now pulseless and no time was lost in giving him a blood transfusion, for matched blood was now in readiness. The gauze pack was removed on the fourth day uneventfully. Convalescence was smooth, the only complication being slight suppuration in the lumbar wound.

It is unlikely that this patient would have recovered if abdominal nephrectomy had been attempted.

When an intra-abdominal lesion is found the wound must be enlarged as necessary and the ruptured viscus dealt with effectively. Then, and then only, is the time to decide whether the patient is in dire need of operative treatment for the renal lesion. It is often good judgement to close the abdomen, return the patient to bed, and to treat the renal injury expectantly, at any rate *pro tem.* On the other hand, if there is a considerable retroperitoneal hæmatoma in a renal area and the patient's general condition is satisfactory it is advisable to proceed. It is difficult to determine the extent of the renal damage if the posterior layer of peritoneum has been opened over the kidney, and such a step often results in nephrectomy being performed unnecessarily.

Transabdominal nephrectomy is particularly hazardous, bears a high mortality, and should rarely be undertaken (Meredith Campbell). To proceed as in the case quoted above is the better course.

Dual Injuries.—As would be expected, the outcome of severe injury to more than one organ is always doubtful. It is therefore encouraging to learn that of 46 cases of the commonest dual lesion—ruptured spleen and left kidney—treated by combined splenectomy and nephrectomy collected by R. Desjacques before the era of blood banks, 22 recovered.

The Triad of Injuries.—Concomitant ruptured left kidney and ruptured spleen is not infrequently associated with rupture of the left side of the diaphragm. This triple injury is the result of crushes or high velocity impact upon the left side of the trunk. When the diaphragm is torn, usually the stomach herniates into the thorax; consequently the most important radiological sign of a ruptured diaphragm is elevation of the gastric bubble. Adams and Musselman, in discussing this triad of injuries, have found that the thoracic approach with enlargement of the diaphragmatic rent has allowed them to perform splenectomy and left nephrectomy. After inserting a drainage tube through the left flank the diaphragm is repaired and the thorax closed with water-seal drainage.

A Concrete Diagnosis of Uncomplicated Ruptured Kidney has been made. Indications for Exploration by the Lumbar Route. (For technique see p. 610.)—

1. The immediate hæmorrhage is severe enough to endanger the patient's life.
2. The hourly pulse-reading is rising.
3. Unabating hæmaturia continuing more than 24 hours.
4. Persistence of considerable local rigidity and tenderness for a like period.
5. Large perinephric hæmatoma discernible within the first 48 hours.[1]
6. Pyelographic evidence of a major lesion.

In about 90 per cent of cases the kidney is the only organ damaged and the rupture is extraperitoneal. Consequently it is *lumbar* exploration that is indicated in nearly all cases.

Determining the Presence of the Other Kidney.—Reference has been made already to the inestimable value of excretory urography in this respect.

When pyelographic evidence is not available the surgeon should reflect on the fact that congenital absence of one kidney occurs sufficiently frequently to make it imperative to ascertain the presence of a second organ. It is never permissible to neglect this step, as the following unfortunate coincidence emphasizes.

A patient, having been gored in the loin by a bull, was rushed to a hospital in the nearby city. His lacerated kidney was removed promptly, but he passed no urine, although he survived for several days. Necropsy showed that the only functional organ had been excised. A few months later, into the same hospital was admitted a second patient who had been gored by a bull. It was found that the kidney had been wounded, and it was removed. He, too, passed never a drop of urine, and the post-mortem revealed that the contralateral organ was congenitally absent.

It is possible to prove the presence of the contralateral organ by chromocystoscopy. An irrigating cystoscope is essential, for the bladder probably contains blood-clot. When the surgeon is familiar with the use of the irrigating cystoscope, and has available the services of a competent theatre staff, unless the condition of the patient brooks of no delay this measure is practicable.

A general anæsthetic sometimes inhibits the excretion of dye by the kidneys; moreover, cystoscopy in the presence of blood-clot in the bladder may prove time-consuming. It is for these reasons that it is recommended that this investigation should be carried out before a general anæsthetic is administered. With suitable preliminary medication cystoscopy can be performed under local anæsthesia, or better still, under low spinal anæsthesia, which does not add to shock. In necessary cases blood transfusion or plasma can be given while cystoscopy is in progress.

Theoretically, when the condition of the patient or other circumstances make chromocystoscopy impracticable, the information required should be made available by opening the peritoneum in the ventral portion of the lumbar incision, and after having the patient rolled sufficiently to enable one to insert the hand into the peritoneal cavity, to palpate the kidney of the other side. Having obtained the necessary information, the peritoneum is closed. I have tried this expedient, and have found that it is possible, but time-consuming and disturbing to the even tenor of the operation. It is my conviction that in extenuating circumstances the interests of the patient are best served by making a

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[1] Shattered kidney is a prime indication for urgent operation. The condition is manifest by unrelenting shock and a rapid increase in the size of a mass in the flank.

small midline incision in the anterior abdominal wall, and through this ascertaining the presence of the contralateral organ the existence of a perinephric hæmatoma on the affected side and the absence of an intraperitoneal lesion. Armed with this knowledge having sewn up the anterior incision rapidly the patient is turned over and the surgeon can proceed with a set lumbar operation in an orderly manner and with a quiet mind that is the outcome of an established diagnosis.

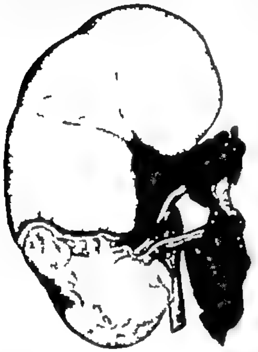


Fig. 805 —Anæmic infarction of the lower pole of the kidney (*A. Fullerton, British Journal of Surgery*)

NEPHRECTOMY

(*for* Technique, *see* p 614)

Indications.—

1 The vascular renal pedicle is torn.

2. The ureter is avulsed.

3. The parenchyma is lacerated in several places.

4 There is a tear extending towards the renal pelvis, but the kidney has a short pedicle and cannot be delivered completely it is impossible to suture a rent that cannot be displayed.

5. Anæmic infarction. It is dangerous (severe sepsis secondary hæmorrhage) to conserve infarcted tissue. *Fig* 805 shows the coloration of the tissue of which to beware Nephrectomy or partial nephrectomy is always indicated in the presence of infarction.

When the renal pedicle has been surrounded by blood and blood-clot for more than 48 hours it becomes friable and a mass ligation around its constituents is liable to cut out. For this reason it is essential to exercise special care in applying ligatures to the renal vessels. Segmental ligation (*see Fig* 820 p. 614) should be the unwavering rule. In desperately urgent cases, rather than consume time in ligating the renal pedicle occasionally it is good judgement to rely on hæmostats, which are left in position The wound is closed with the minimum of sutures indeed on one occasion I left the wound entirely unsutured The hæmostats are loosened and removed on the third or fourth day

CONSERVATIVE OPERATIONS

In cases of injury to a kidney it is conservative to operate early when in doubt, operate.
(O S. Lowsley)

If displayed within 24 hours many ruptured kidneys that later would require nephrectomy can be saved Various procedures are available which to employ requires surgical judgement. The nature of the lesion, the experience of the operator and the facilities available are all factors that must be taken into consideration.

Packing.—When a sole existing kidney is ruptured, when the presence of a contralateral organ has not been ascertained, when the condition of the patient is poor when the operator is relatively inexperienced and the facilities available in the matter of assistance are inadequate this expedient has everything to recommend it. Three rolls of gauze are required. Having cleared the perinephric space of blood and blood-clot, one piece of gauze is packed on the medial aspect of the kidney another on the lateral aspect, and a third fills the wound. The skin is brought together loosely The patient is watched most carefully Blood transfusion is given, as necessary In the unlikely event of excessive hæmaturia or oozing under the dressings, the wound must be reopened without any delay Usually a second stage can be safely postponed until the third day Then under the best possible conditions that can be arranged (and by this time a better knowledge of the function of the contralateral kidney if present having been obtained) the packing is removed.

The kidney will be found in a much less alarming state instead of being congested and bleeding, it will be dry and relatively anæmic. It should be scrutinized carefully for anæmic infarction. It may well be that another of the conservative measures can be carried out or even that the kidney can be dropped back into the wound with a reasonable assurance that healing can occur. The wound is sutured and a ¼ in. (6 mm.) drainage tube provided.

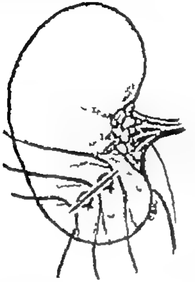


Fig. 806.—The edges of the rent having been approximated, three stitches are passed as shown. These will be tied over a muscle-graft.

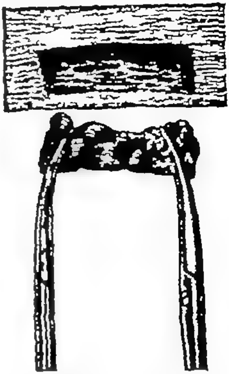


Fig. 807.—A muscle-graft taken from the sacro-spinalis. The forceps make an efficient spreader whilst the muscle is being transferred to the kidney and sutured into position.

Suture.—All of a sufficient number of mattress sutures to close the rent are inserted before they are tied. Each stitch is passed through the parenchyma to a depth of about ¼ in. (6 mm.) The catgut must be pliable, and the knot tightened steadily so as to avoid a sudden jerk.

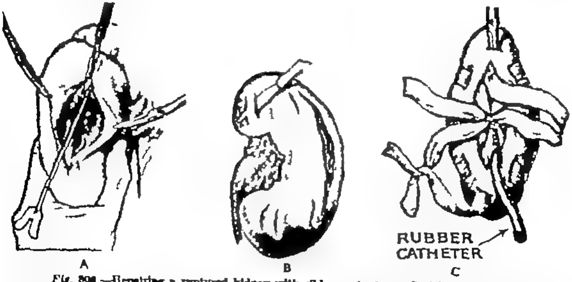


Fig. 808.—Repairing a ruptured kidney with ribbon catgut. A, Incising the capsule. B, Cutting slot in the capsule; C, Standard method of binding the kidney with ribbon catgut. In this instance nephrostomy was performed in addition. (*After Lowsley and Menning.*)

These sutures are not tied tightly (*a*) to prevent cutting out (*b*) to obviate strangulating renal tissue included in the mattress (see *Fig.* 740 p. 533). The edges of the wound having been approximated satisfactorily three further stitches are passed (*Fig.* 806), one near

one end of the laceration, one near the other and one in the middle but they are not yet tied. A muscle-graft (*Fig* 807) is cut, and the sutures referred to are tied over the graft to reinforce the suture line In place of a muscle-graft absorbable gauze or gelfoam can be used, but they offer no advantage over muscle which is material *par excellence* for this purpose Repair by suture should be limited to solitary linear tears. In tears of the middle of the kidney communicating with the caliceal system suture can, with advantage be combined with nephrostomy A small catheter with a second eye cut near its termination is passed into the renal pelvis, and the rent on either side of it is repaired in the manner just described.

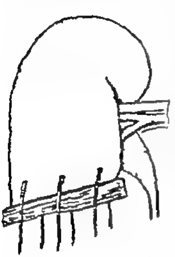


Fig 809 — Partially avulsed lower pole treated by completing amputation and covering the raw area with a muscle-graft.

Binding the Kidney with Ribbon Catgut is an alternative procedure to the above Provided Lowsley s ribbon catgut is available and the surgeon is experienced in renal surgery and the patient is in good condition, this method can be used from time to time. The renal capsule is opened along the convex border Clots and loose pieces of renal parenchyma are removed. After constructing slots in the capsule in the manner shown in *Fig* 808 ribbon catgut is employed to bind the ruptured organ.

Partial nephrectomy : *Indications.*—

1 When the damage is confined to one pole

2. Anemic infarction limited to the lower pole.

The raw surface left after removal of an avulsed pole (nearly always the lower pole) is well safeguarded by stitching an ample muscle-graft against it (*Fig* 809). Less kidney substance is wasted than in the customary wedge-shaped method of repair (Campbell Begg) the sutures are in less danger of cutting out, and dead space is obliterated. After this method of repair post-operative bleeding urinary fistula and sloughing are conspicuous by their absence

Emphasis has been placed upon the necessity of removing infarcted renal tissue When the area is localized strictly to the lower pole it should be excised in the customary V-shaped manner after stripping back the capsule The edges are approximated by suture the capsule is sutured over the stump which is reinforced by a muscle-graft In cases of infarction a torn aberrant renal artery should be sought and, if present, ligated.

CONSERVATIVE TREATMENT OF RENAL INJURIES

Although much emphasis has been placed upon operative measures, the indications for them have been defined clearly In about 70 per cent of cases if the patient is treated as described on p. 393 operation never becomes necessary The rationale of conservative treatment lies in the fact that bleeding from an injured kidney tends to be self limiting This is due to the tamponade effect of the true capsule if the tear is intracapsular or of the perirenal fascia if the tear is extracapsular Thus, unlike the liver or the spleen, the kidney may be said to possess a double capsule.

The attitude to be adopted in injuries of the kidney is to be prepared to operate but to withhold one's hand unless there are definite indications that the damage calls for more help in repair than Nature can provide Furthermore however seemingly well the patient may appear one must not relax the vigil on the pulse temperature and urine for at least ten days. Above all there must be no early rising —strict bed rest is the order of the day It is most instructive and a great safeguard to watch the progress of the case with the assistance of serial excretory urographs. In hospitals with a portable X ray machine this routine should always be followed.

RUPTURE OF A DISEASED KIDNEY

A surprisingly high proportion of ruptured kidneys are found to be diseased. In a series of 20 cases of injury to a kidney requiring exploration I found 6 to be abnormal. Of these 4 showed varying degrees of hydronephrosis, 1 contained a calculus, and 1 was a congenital cystic kidney In only 2 of these cases was the injury comparatively slight—falls to the ground while walking in the street

In a radiological investigation of renal injuries M R Hall also was surprised at the high incidence of pre-existing disease of the injured organ In no less than 23 per cent the ruptured kidney showed clear radiological evidence of disease which was later confirmed at operation. None of the patients was aware that the kidney was abnormal

In cases of rupture of a considerable hydronephrosis it is the renal pelvis that is usually torn, and consequently the symptoms are unlike those of rupture of a normal kidney there is no hæmaturia.

H W L. Molesworth's Case —A woman of 50 fell and struck her left side Violent abdominal pain followed, and shortly afterwards she vomited. When examined, abdominal rigidity was evident especially on the left side Under general anæsthesia an abdominal swelling was apparent. The abdomen was opened, and a large retroperitoneal swelling was found. The laparotomy incision was closed and a ruptured hydronephrotic kidney was removed by the lumbar route Recovery

Coincident tearing of the overlying peritoneum has been found in 25 per cent of cases of ruptured hydronephrosis. When a hydronephrosis has ruptured into the peritoneal cavity abdominal nephrectomy should be undertaken. If however the fluid mass is extraperitoneal, unless the pre-operative diagnosis is assured (in which case lumbar exploration is carried out), the correct method of procedure is as described in the above case When the kidney of the opposite side is diseased and the wall of the hydronephrosis contains even a small amount of kidney substance an endeavour should be made to save the organ by stitching it up around a drainage tube

TRAUMATIC PERIRENAL HÆMATOMA

Although there is no need for haste it is better to drain a palpable perirenal hæmatoma and, at the same time, explore the damaged kidney within 24 to 48 hours of the accident. To adopt an expectant attitude is to take unjustifiable risks, for without the aid of retrograde pyelography the extent of the laceration is unknown. Other reasons for advising early operation are that these extravasations of blood are liable to become infected even should they resolve—a slow process—further trouble is not necessarily at an end. I have met with two cases where the contracture of fibrous tissue resulting from the resolution of a perirenal hæmatoma literally strangulated the kidney within it. In late cases of perirenal hæmatoma (by which is meant that the patient first comes under observation upwards of six days after the accident) when his general condition is good and there is no hæmaturia, it is best to drain the collection of blood with the least possible disturbance to the kidney In some instances the extravasated blood burrows along the sheath of the psoas muscle towards the iliac fossa exceptionally it tracks along the spermatic vessels and produces ecchymoses at the external abdominal ring In two such cases ten days after the accident, a large quantity of dark blood was drained by making a gridiron incision as for appendicectomy When the peritoneum was reached it was pushed medially and the retroperitoneal tissues were opened up with the finger In suitable cases this is an excellent expedient, for the extravasated blood is drained from its lowest point with minimum disturbance to the ruptured kidney which by this time is most probably in a stage of natural repair

Spontaneous Perirenal Hæmatoma.—The classical triad of abdominal pain, signs of internal hæmorrhage, and a swelling in the loin, are often obscured by the resemblance to an acute abdominal catastrophe. There is no single underlying cause—some cases are due to bursting of an aneurysm of the renal artery others are caused by renal neoplasms or inflammation, still others are probably due to obstruction of the renal veins. In a few cases the cause has been found to be periarteritis nodosa. Without operation the condition is said to be always fatal. The largest proportion of recoveries have followed urgent nephrectomy and it is advisable to carry out this step in most cases. In unfavourable circumstances this is an occasion for the use of *packing* (*see* p 588). When necessary the kidney can be removed at the second stage of the operation.

INJURIES OF THE URETER

Traumatic Rupture of the Ureter is very uncommon. Avulsion of the ureter proper from the pelvis of the kidney is the most usual variety The lower third of the ureter has been wounded by a spicule of bone from a fracture of the pelvis. Rupture of the ureter often remains unrecognized until extravasation of urine into the deep planes of the loin arrests attention by causing a lumbar swelling. Perirenal extravasation of urine needs drainage. One is fortunate if in the course of carrying this out, the site

of leakage can be displaved; more often drainage is all that can be accomplished in the first instance.

If repair is possible, end-to-end anastomosis of the ureter (*see below*) will be the most generally applicable measure.

Injuries to the Ureter during Hysterectomy and other Pelvic Operations occur rather commonly, doubtless much more frequently than would appear from the literature. The accident could be minimized considerably by the preliminary passage of ureteric catheters. As a result of the operation accident the ureter is sectioned transversely or obliquely or a piece may be removed from its side wall. More often the ureter or ureters are occluded by a ligature, or ligation of a blood-vessel in the immediate neighbourhood causes an obstructive kink. Finally, an occasional complication after radium implantation for carcinoma of the cervix is necrosis of the juxta-cervical portion of the ureter which leads to a urinary fistula.

The site of the lesion is usually in the broad ligament near the uterine artery (*see Fig.* 773, p. 560), but it sometimes occurs somewhat higher. The injury may be recognized (1) at the time of the accident, (2) during the immediate post-operative period, or (3) later.

INJURY RECOGNIZED AT THE TIME OF THE OPERATION

It is highly important to recognize the divided ureter promptly and avoid being lulled into the belief that it is a vessel which has been clamped and severed. A divided ureter pouts, whilst a divided artery retracts (*Fig.* 810). A divided ureter also shows its classical worm-like peristalsis on gentle pinching.

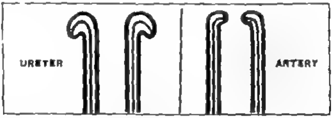


Fig. 810.—The differential diagnosis between a cut ureter and a blood-vessel. The divided ureter pouts, whilst a divided artery retracts.

Having satisfied oneself that it is the ureter which is damaged, several alternative procedures are available. Each will be discussed and its relative merits and demerits explained:—

1. **Ligation of a Cut Ureter *per se*** should be condemned. It is true that, provided the contralateral kidney is healthy, in 58 per cent of cases renal atrophy follows quietly. But what of the remaining 42 per cent? Three per cent die of renal failure, 24 per cent develop a fistula, and 15 per cent require nephrectomy for hydronephrosis that is often infected (A. B. Hepler). Ligation followed by temporary nephrostomy which, in cases where speed in concluding the operation is imperative, can be postponed for 24–48 hours, has much to recommend it. A reparative operation or, failing that, nephrectomy, can be undertaken in two or three weeks time.

2. **Cutaneous Ureterostomy** has its advocates, but the disadvantage is that it shortens the ureter available for subsequent implantation into the bladder. Moreover in a not inconsiderable percentage of cases the distal half-inch (1·3 cm.) of the ureter sloughs, making implantation into the bladder less feasible.

3. **Abdominal Nephrectomy.**—On two occasions I have been summoned to the operating theatre to perform abdominal nephrectomy when the gynæcologist considered it unwise to attempt a conservative operation. In one of these cases the kidney, the ureter of which had been divided, was hydronephrotic. When the contralateral kidney is normal this is a certain method of preventing the serious complications of unsuccessful repair. Nevertheless to remove a healthy kidney is not in keeping with the ideals of surgery, and it should be performed only when there are good reasons for not undertaking a restorative operation.

4. **End-to-end Anastomosis.**—Although this is not a difficult procedure it must be condemned because the results are extremely bad. A stricture develops in all (Graham

and Colligher), or almost all cases. In the rare event of the ureter being severed at a considerable distance from the bladder end-to-end anastomosis is the only alternative to nephrectomy The cut ends are trimmed obliquely and four 000 plain catgut sutures are used to effect the anastomosis (*Fig* 811). The best way of affording rest to the suture line is to incise the ureter vertically above the anastomosis, and insert a ureteric catheter into the pelvis of the kidney The catheter is retained for a week.

5. Implantation of the Ureter into the Bladder.—Provided the operation is carried out extraperitoneally with drainage to the site of implantation and drainage of the bladder suprapubically or by an indwelling catheter the results are excellent, especially after the Boari operation (*see below*)

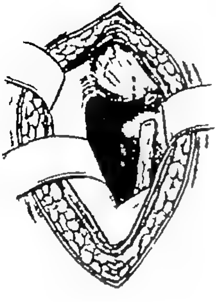
The lower end of the ureter can be exposed extraperitoneally through an incision comparable in every way to that described for displaying the external iliac artery (see p 930), but the incision is carried to the middle line just above the pubic symphysis. Kiss and Holzer have employed this incision in 18 cases of cut ureter and speak highly of it The ureter adheres to the peritoneum, and as the latter is lifted from the bifurcation of the common iliac vessels the ureter will be displaced. It is mobilized from the peritoneum in an upward direction for at least 6 in (15 cm.) The bladder is distended with 200–300 ml of water in order to facilitate exposure of the lateral bladder wall The lower end of the ureter is ligated if it can be found conveniently

Fig. 811 —End-to-end anastomosis of a ureter

Method 1 —When the ureter is of sufficient length to lie without tension on the bladder wall, this simple method suffices. The ureter is bisected longitudinally for ½ in. (1·3 cm). A mattress suture of 000 plain catgut is inserted into each flap from within, outwards. A stab incision is made through the bladder wall in an oblique direction to imitate the intramural course of the ureter The split ureter is carried into the bladder by means of passing the attached sutures through the bladder wall from within, outwards (*Fig* 812) It is important that these sutures should be passed far enough from the incision in the bladder to splay the flaps completely The sutures are tied, the opening in the bladder is closed snugly around the ureter and the anastomosis is reinforced by the two sutures passing through the adventitia of the ureter and the superficial part of the bladder wall The abdominal wall is closed with corrugated rubber drainage down to the site of the anastomosis this should not be removed completely for 5 days. An indwelling catheter is retained for a week. Penicillin and sulphatriad are administered for at least 10 days.

Fig. 812.—Implantation of the ureter into the bladder

Method 2 (*the Boari Operation*).—When it is found that the ureter is too short to lie on the bladder wall without tension, a ureteric catheter is placed in its upper portion to divert the urinary stream for a while A rectangular flap of bladder is outlined (*Fig* 813 A) The bladder is then emptied. The flap is cut in such a way as to leave it hinged at its base which should be near the trigone (*Fig* 813 B) The ureter is then split longitudinally as in method 1 and it is anchored to the distal part of the bladder flap as shown in *Fig* 813 inset. The ureteric catheter is reinserted. The flap is rolled around the catheter to form a tube and the edges are united by closely placed interrupted sutures of 000 plain catgut placed with minute care into the bladder musculature The distal extremity of the newly formed tube of bladder is united to the adventitia of the emerging ureter with similar sutures. Into the opening into the bladder from which the pedicle graft was cut is placed a Malecot catheter This portion of the bladder is closed about the Malecot and ureteric catheters (*Fig* 813 C) which are brought out of the abdominal incision at a convenient place The prevesical space is drained The Malecot and ureteric catheters are withdrawn on the sixteenth day and a urethral catheter substituted for a further few days. Urinary antiseptics are given during the post-operative period, as directed in method 1



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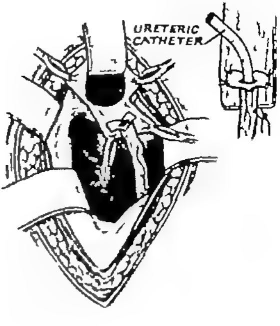

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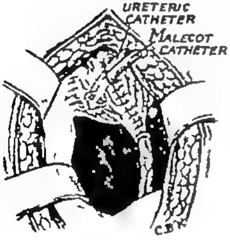

C

Fig. 813.

A, The bladder flap is outlined.

B The flap is cut, and the split ureter is ttached to the mucosal surface of the distal part of the flap as shown in inset.

C, Tube pedicle graft of bladder completed. The Malecot catheter inserted into the bladder, and the wound closed around the Malecot and ureteric catheters. (*After E. K. Lowsley.*)

N. B.—For the sake of clarity in this instance the operation is being conducted through a paramedian incision in an unscarred abdominal wall.

Injury recognized during the Immediate Post-operative Period

a. Anuria after Hysterectomy usually means that both ureters have been ligated. On no account should deligation be attempted—it is difficult and dangerous. The correct treatment is bilateral nephrostomy if possible under local anaesthesia. To attempt to explore the abdomen at this stage when structures are oedematous and matted, combined with the uncertainty of finding the occluded ureter is to court disaster. Nephrostomy

(p 619) is a certain method : when the patient is out of immediate danger is time enough to attend to the actual lesion.

R I Day's case.—

A woman of 28 was seen four days after an operation for hysterectomy She had passed no urine since the operation, and the bladder was empty Day performed bilateral nephrostomy Two months later the left ureter was transplanted into the bladder It was found that the right ureter had been sectioned too high for an anastomosis with the bladder so nephrectomy was performed on that side. The patient made a good recovery

J R Caulk's case—

Both ureters had been ligated in the course of a hysterectomy Caulk performed bilateral nephrostomy eight days after the operation. On the fifty-eighth day both nephrostomy wounds closed, the urine coming normally from both kidneys. Five years later this patient was seen, and had been perfectly well in the interval.

This, undoubtedly was a case where the ureters had been ligated with catgut, which ultimately became absorbed.

Accidental Ligation of One Ureter—Often (88 per cent of cases) the patient experiences no symptoms and the kidney atrophies quietly At other times there are early symptoms of lumbar pain or renal colic. Such symptoms occurring after panhysterectomy (abdominal or vaginal), or following excision of the rectosigmoid, should always suggest the possibility of this accident, and call for an investigation of the kidneys. Excretory urography is the simplest method of proving the integrity of the ureters. Failing that, chromocystoscopy should be performed. If one kidney is not functioning urgent nephrostomy is the best course. Possibly a catgut ligature occluding the ureter will be absorbed. During the second week after nephrostomy catheterisation of the ligated ureter should be attempted If this is unsuccessful, the attempt is repeated during the third week and if still unsuccessful, the lower end of the ureter must be explored. Sometimes deligation of a silk ligature is all that is required at others the ureter must be severed and implanted into the bladder

b **Urinary Fistulæ** following accidental wounding of the ureter during *pelvic operations* are usually external. The leak occurs through the abdominal incision or in cases following panhysterectomy through the vagina. Constant seepage of urine from the vagina is often first mistaken for a serous discharge, and later for a mild degree of incontinence of urine sometimes it is many days before a ureteral fistula is considered as a possible cause It is, of course, necessary to differentiate between a leak from a ureter and a leak from the bladder This is accomplished readily by the following procedure. The patient is placed in the lithotomy position, a vaginal speculum is inserted, and the vagina is sponged dry A soft rubber catheter is passed into the bladder which is distended with a solution of methylene blue If the blue fluid is observed escaping into the vagina, it proves that the leak is from the bladder conversely if no blue appears in the vagina but urine continues to escape, it is conclusive evidence that the lesion is in one or other ureter It will then be necessary to make a cystoscopic examination following the injection of indigo-carmine intravenously to decide which ureter is involved. An endeavour is made to pass a ureteric catheter on the side of the lesion In the unlikely event of a steady drip of urine being obtained the catheter is retained and its position in the ureter is ascertained by radiography Excretory urography usually provides additional helpful information.

Less commonly the urinary extravasation is wholly or partially internal, the amount being inversely proportional to the extent of the drainage provided at the time of the operation. Occasionally the urine escapes into the peritoneal cavity giving rise to what is known as urinary ascites. If the urine is sterile the patient does not necessarily become seriously ill for as long as a week, but eventually diffuse peritonitis supervenes.

When sterile urine permeates undrained soft tissues it causes necrosis, sloughing, and suppuration. Infected urine in undrained tissues accelerates this vicious reaction. Extravasation into the retroperitoneal tissues usually gives rise to early symptoms of pyrexia, increased pulse-rate, nausea and vomiting, and the patient becomes gravely ill sooner than in the case of leakage of non-infected urine into the peritoneal cavity

Treatment—To attempt to repair a cut ureter when the tissues are œdematous and probably infected is often difficult, and attended by shock moreover if accomplished, the anastomosis is liable to break down. A far better course is to perform temporary nephrostomy and, if necessary provide freer drainage to the site of the lesion. *In the*

case of urinary ascites suprapubic intraperitoneal drainage is carried out It is inadvisable to attempt a reparative operation for four or five weeks. Following this plan, I implanted successfully the left ureter into the bladder[1] four weeks after it had been cut during an operation for excision of the rectum. Urgent operation is required only in the case of extensive leakage into the retroperitoneal tissues, in which case, provided the contralateral kidney is healthy it is probably always advisable to perform lumbar nephrectomy as soon as the patient can be got into a fit condition to withstand that operation. Blood transfusion is helpful in this respect. When, on account of the poor condition of the patient or the perilous state engendered by the absence of or impaired function of the contralateral kidney nephrectomy is impractical, to expose the kidney on the side of the traumatic lesion, tie its ureter near the renal pelvis, and then perform nephrostomy is the course most likely to succeed.

In all cases antibiotic therapy and the administration of sulphatriad should be commenced at the earliest possible moment, and continued until the patient is convalescent.

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[1] When the gap between the proximal end of the ureter and the bladder is too wide to permit implantation into the bladder the advisability of the interpositioning of a segment of small intestine between these structures or though less desirable, implantation of the ureter into the bowel, should be weighed carefully in cases where the function of the contralateral kidney is impaired.

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CHAPTER LIII

OLIGURIA, ANURIA, AND URÆMIA

OLIGURIA should be defined as an excretion of less than 20 oz. (568 ml.) of urine in 24 hours Anuria is an absence of excretion for 12 hours or more

For purposes of diagnosis and treatment there is no better classification of anuria than —

1 *Pre renal anuria (syn circulatory renal insufficiency)* due to a fall in the blood pressure below the point where excretion of urine is possible

2. *Renal anuria consequent* upon failure of renal epithelium to excrete urine

3 *Obstructive (syn post-renal) anuria* Necessarily this must be bilateral or involve a sole functioning kidney

After taking a careful history and making a clinical examination that includes taking the blood pressure, it is nearly always possible to classify the case in accordance with the above table. Then, and then only is the surgeon in a position to commence the correct treatment—so dissimilar in each of the three varieties of anuria. Should there be facilities for an estimation of the blood urea, no time should be lost in taking advantage of them.

PRE-RENAL ANURIA

Pre-renal Anuria due to Peripheral Circulatory Failure.—Normally the blood-pressure in the glomeruli is about 90 mm. Hg; when the systolic blood pressure falls below 70 mm Hg filtration from the glomeruli ceases. If the glomeruli are diseased, a higher pressure up to 100 mm. Hg may be inadequate to maintain filtration.

The causes of pre-renal anuria are traumatic shock severe hæmorrhage spinal anæsthesia, extensive burns, dehydration from vomiting diarrhœa or excessive sweating, and cardiac failure.

Often this form of suppression of urine develops when least expected and when, rightly treatment is being directed towards resuscitation of a shocked patient. In the concern to restore an adequate blood pressure those in attendance are liable to miss by many hours the fact that the patient has passed no urine What is unpardonable having restored the blood pressure to a satisfactory level, is to forget to ascertain whether the patient has passed urine and if he has not done so, to continue to load the circulation with fluid and electrolytes. This rather frequent happening so disrupts the patient's fluid and electrolytic balance as to prejudice his ultimate recovery from anuria. Unquestionably the treatment of peripheral circulatory collapse must be pursued in the presence of anuria, always hoping that the rectification of the first condition will remedy the second, but if within half an hour of the restoration of an adequate blood pressure no urine has been passed since the treatment was commenced, and little or none can be obtained by catheterization the drip should be slowed to an absolute minimum, and on no account is an electrolytic solution permitted the further administration of blood (if any has been given) is inadvisable—only plasma, or better dextran, should be employed. Dextran 6 per cent in 5 per cent dextrose is now available and it is better than dextran in saline solution for patients who are unable to excrete sodium chloride As soon as it is considered safe to do so, the drip is stopped.

When hypotension and its resultant anoxia is of long duration damage to the renal epithelium results, and the condition passes on to one of renal anuria. During anuria due to shock, cortical necrosis can occur and if this is complete the prognosis is hopeless but this must never be assumed because when the lesion is less extensive and the main changes are confined to the renal tubules, the prognosis is good, provided the treatment of renal anuria described on p. 509 is commenced as soon as practicable.

Pre-renal Anuria due to Dehydration is relatively uncommon, and its treatment is the antithesis of the foregoing That the patient has lost a prodigious amount of body fluid is usually obvious. The amount of fluid replacement required can be estimated by the

specific gravity of the plasma a method of ascertaining this in the side room is described on p. 1083 As a rule, the fluid loss is remedied by the administration of dextrose-saline solution intravenously which usually restores urinary excretion.

RENAL ANURIA

Non-obstructive is much more frequent than obstructive anuria (Styron and Leadbetter).

Acute renal failure is a disease of which patients frequently die because of mismanagement (Swann and Merrill).

Renal anuria results from damage or destruction of the renal epithelium (*Fig* 814). The *principal causes of renal* anuria met with in *surgical and gynæcological practice* are —

1. Incompatible blood transfusion (*see* p. 63).
2. Ultra-acute pyelonephritis, especially that occurring with retention of bladder urine.
3. Traumatic anuria.
4. Concealed accidental uterine hæmorrhage
5. Reflex anuria.
6. Acute pancreatitis.
7. Congenital polycystic kidneys.
8. Advanced bilateral renal tuberculosis.

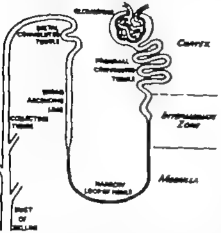

Fig 814 —Necrosis of the proximal convoluted tubule produces immediate anuria in that nephron. Renal ischæmia lasting two hours results in death of the epithelium of these tubules. (*H L. Sheehan.*)

Although acute renal failure is commonly and conveniently referred to as anuria, cases in which collection of urine has been undertaken carefully by catheterization show that at least a small volume of urine (sometimes less than 50 ml.) is passed daily The patchy distribution of renal tubular lesions seen at necropsy and the continued urinary flow however scanty are proof that some nephrons are functioning partially or completely

The average duration of the oliguric phase is about 10–12 days. The clinical findings during the first few days are largely those of the causative condition and/or a result of over-administration of salt or water If the former resolves and the latter is no longer allowed to occur towards the end of the first week the main symptoms are lethargy and nausea indeed the paradoxical situation of clinical improvement with progression of abnormal blood chemistry is often encountered.

Unless diuresis sets in, during the second week clinical deterioration follows. Vomiting usually commences. Oral feeding aggravates the vomiting which frequently lessens or *subsides when the intake is shifted from the oral to the intravenous route. Abdominal* distension is seldom absent. The systolic blood pressure even in a young, previously healthy adult, rises to between 140 and 200 mm. Hg As a rule diarrhœa does not develop until late in the oliguric phase, or until after the onset of diuresis. With prolonged oliguria somnolence may progress to stupor mild delirium, or coma. Convulsions in oliguria nearly always signify excessive administration of water and sodium.

Contrary to earlier beliefs, the most important substances in the genesis of uræmia are not urea and the other organic end products of nitrogen metabolism, but water and electrolytes. The manifestations of the more common of these aberrations of water and electrolytic balance are in order of frequency —

Over hydration —One of the earliest signs is a full external jugular vein (*see Fig* 115, p 63). Pitting œdema should be looked for

Acidæmia.—The clinical picture is dominated by deep sighing respirations, and is accompanied by various degrees of progressive clouding of consciousness. The most common accompaniments are restlessness, headache and nausea. The diagnosis can be substantiated by a reduced bicarbonate level

Hyperpotassæmia.—The reprehensible practice of prescribing *potassium* citrate for a patient on the threshold of anuria has caused many deaths. On the other hand, the high-carbohydrate–no-protein diet reduces the incidence of this much feared complication very considerably It is unfortunate that in most patients there are no presenting symptoms and signs of hyperpotassæmia. The patient dies suddenly of cardiac arrest. Adequate warning of progressive hyperpotassæmia can be obtained by serial electrocardiography

and serial determinations of the concentration of serum-potassium. Neither is an adequate substitute for the other. For other aspects of hyperpotassæmia see p. 603.

Hypopotassæmia.—In the early diuretic phase of tubular necrosis, hypopotassæmia is prone to occur due, it is believed, to a tubular defect in the resorption of potassium. Hypopotassæmia is discussed on p. 34.

THE MANAGEMENT OF RENAL ANURIA

Water Balance.—The danger of over hydration of an anuric patient is greater than that of under hydration, and the previous daily allowance of 1 litre of water to balance the insensible loss through the lungs and skin is now considered excessive in a temperate climate. It is estimated that there is a daily production of 400 ml. of water from the oxidation of body fat and proteins, consequently to avoid over hydration the daily fluid intake should be limited to 500 ml. plus an amount equal to that of the water vomited or recovered by gastric aspiration. Particularly unsound is the rule of thumb that the amount of vomitus should be replaced by an equal amount of normal *saline* solution. The frequency with which attempts to correct sodium loss by giving solutions containing sodium have eventuated in cardiac failure has led to increasing reluctance to administer sodium during the oliguric phase. Additions must also be made for excessive sweating, and for diarrhœa.

As opposed to laboratory tests, bed-side evaluation—thirst, moisture of the oral mucous membrane and the skin, the amount of vomitus, and the condition of the lungs—is an excellent guide as to whether the ration of 500 ml. of water should be exceeded in a patient who is virtually a closed system in regard to the excretion of water and salts. In essence, the intake of fluid above the bare minimum should be governed by the patient's thirst. When the weather is exceedingly hot, tea or water sweetened with lactose just sufficient to slake thirst, is allowed but even in these circumstances the fluid intake should rarely exceed 1000–1200 ml. per 24 hours.

Electrolytic Balance.—From the above remarks, it will not be a surprise to learn that the patient must not receive any electrolytes until diuresis has commenced. When, as is usual, there is a depression of chloride and HCO_3 ions without specific symptoms of lack of these substances, this should be looked upon as adaptive, and in no way a call for meddlesome adjustment.

Daily Carbohydrate Intake.—The diet now recommended is entirely carbohydrate. This not only supplies the necessary number of calories, but obviates the catabolism of exogenous protein and minimises the catabolism of endogenous protein, both of which release potassium. The potassium freed by protein catabolism is far more injurious than the nitrogenous waste products thus produced. Incidentally as a result of a protein-free high carbohydrate diet the production of the latter is reduced greatly (*Fig* 815). Bull advises a daily intake of 300 C to prevent hyperpotassæmia due to tissue breakdown. The earlier diet, supplementing carbohydrate with fat, is now not recommended, for two reasons: (1) Fat increases the nausea and vomiting of uræmic states (2) Fat, especially some batches of pea nut oil (the fat that was employed widely for this purpose) provokes diarrhœa.

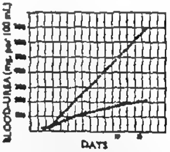

Fig 815.—Dotted line, rise of blood urea in untreated renal anuria; Solid line, the same when treated by fluid limitation and a carbohydrate diet. (*After G M Bull.*)

The choice of a particular carbohydrate, its concentration, and the route by which it is to be administered, requires careful consideration. When the patient can take fluid by mouth without vomiting or undue nausea, a daily intake of 500 ml of 20 per cent lactose given in small frequent amounts is likely to be acceptable because the solution tastes less sweet than dextrose (Oard and Walker). When, as is often the case the anuric patient is anorexic, nauseated, and prone to vomit at the least provocation, it is imperative to give the daily allowance of water and carbohydrate intravenously. When the daily intake of carbohydrate has to be administered intravenously it must be given in a concentrated solution—40 *per cent dextrose*—in order to supply the necessary amount of dextrose without exceeding the 500 ml. limit of water. Because solutions in this high concentration cause thrombosis when administered into a peripheral vein, a fine polythene tube should be passed into the inferior vena cava (*see* p. 20) where the

solution becomes rapidly diluted as it is swept into the large volume of blood returning to the heart.

The Daily Vitamin Intake should be identical with that of a patient subsisting wholly on parenteral feeding (*see* p. 81).

The Prevention and Control of Infection.—In acute renal failure a very frequent cause of death is intercurrent infection, therefore all who come in contact with the patient should be gowned and masked, and 1 000 000 units of penicillin given each day in a single dose. Because of the renal failure all antibiotics are excreted at a reduced rate This is of no importance in the case of penicillin, but with other more toxic antibiotics it soon leads *to a dangerous concentration in the body Consequently when it is necessary to administer* an antibiotic other than penicillin to an anuric patient, the dose must be reduced to half or quarter of the usual dose and the level of the blood urea is a good guide as to which of these amounts should be chosen. Penicillin excepted, erythromycin 2 G on the first day and 1 G on the following days seems to be the antibiotic against which least objection can be made (W J Kolff)

Hormonal Treatment.—When they are given the anabolic hormone testosterone nephrectomized animals survive longer than controls. Therefore it is advised to give 5–10 mg of this hormone per day which does no harm, and may be beneficial.

Waiting for a Resumption of Renal Activity.—As the days go by and the anuria persists, naturally the surgeon's anxiety concerning his patient increases. The unknown factor is whether or not the renal damage is limited mainly to the tubules. It should be envisaged that the epithelium of the tubules is capable of regeneration, and that tubular regeneration commences on the second day and is often complete by the fourteenth day Of course should the tubules merely be blocked by hæmoglobin casts, and the epithelium comparatively undamaged resumption of excretion of urine occurs earlier When by the seventeenth day little or no excretion has occurred at least some glomerular damage must be presumed.

Acute Progressive Unrelenting Renal Failure is usually caused by either (*a*) A prolonged period of shock (*b*) extensive cortical necrosis in cases of premature separation of the placenta. There is extensive damage to the upper as well as the lower portion of the renal tubules, and probably necrosis of many glomeruli There is no means of distinguishing this variety of anuria from that in which the lesion is reversible except by the passage of time the stage of diuresis is never reached.

Diuretic Phase is defined as commencing when the daily urinary volume exceeds 400 ml The rate at which the urinary volume increases from day to day in the latter part of the oliguric phase bears a relation to the duration of the oliguria. It increases slowly when the oliguric phase has lasted two weeks or more, it increases more rapidly when oliguria is of shorter duration. The onset of diuresis warrants as much careful vigil as appertained during the anuric phase *25 per cent of deaths occur after the* onset of diuresis. Although the fluid intake must be increased for the first three days it should not be equal to the insensible loss plus the amount of urine passed rather the balance must show a slight deficit on the intake side Most patients lose much weight during diuresis, indicating previous over-hydration despite rigid fluid restriction and the absence of clinical signs of œdema during this period It must be assumed that the over hydration takes place before the restricted fluid régime is instituted, and that the cellular fluid excess is not unloaded during the anuric phase In cases where the oliguric period is of short duration, rapid improvement often follows. When the urinary volume increases slowly and particularly in cases in which the oliguria is prolonged more than two weeks, the effects of renal insufficiency continue to progress, and rapidly progressing hyperpotassæmia, acidosis, delirium, convulsions, or pulmonary congestion may mar the hopeful issue Too often these complications are the result of disregarding the therapeutic principles that staved them off during the oliguric phase or witholding therapeutic adjuncts (*see* p. 001) when they are indicated.

In the early days of the diuretic phase the urine excreted is little more than a glomerular filtrate it must be analysed each day and on the findings sodium chloride is administered very cautiously The fluid intake is increased gradually to approximately 2 5 L daily and later in the diuresis an intake of sodium approximately 75 mEq daily is what should be given in an average case, but it should be governed by frequent analyses of the urine for sodium and chloride loss. It is apparent that excessive diuresis is not always due to

the inability of the renal tubules to resorb water and salts but rather that there is an excess of salt and water in the body Failure to recognize this explanation and to attempt to replace early losses increases and perpetuates the diuresis. A low-grade fever usually commences in the second week of the diuretic phase The temperature is elevated, usually not more than 1½ F (0·8 C.).

Excessive Diuresis.—Sometimes during the stage of diuresis the volume of urine becomes excessive due to :—

1 Deficient resorption of water and electrolytes from the damaged tubules.

2. The overload of urea for excretion.

Polyuria brings the threat of excessive electrolyte loss. When required, electrolytes should be supplied, if possible by mouth. A correct amount of sodium chloride should be given each day By repeated checking this has been found to be 50–75 mEq per litre of urine passed (G M. Bull) Fruit juices, allowed *ad libitum* usually supply sufficient potassium to maintain equilibrium Should the serum potassium fall below 3 5 mEq per litre, potassium citrate 3–5 G dissolved in water or fruit juice can be given three times a day When the urinary volume exceeds 3 l per 24 hours, it is preferable to resort to a 12 or even a 6-hourly schedule of replacement otherwise serious deficits of water and salt are liable to develop

After the urinary flow has become satisfactory and stabilized, death from bronchopneumonia or pulmonary embolus is a discouraging outcome in some of these patients.

ADJUVANT METHODS OF TREATMENT

A major achievement of recent years has been the recognition that an organic lesion capable of natural repair is responsible for the oliguria in many cases of acute renal failure. As a result renal denervation, renal decapsulation, and diuretic agents to stimulate urinary flow have been abandoned. Nevertheless, excellent as it is in the majority of cases, a strictly limited fluid intake combined with a pure carbohydrate diet will not save all patients.

Exchange Transfusion.—The chief indication is in the initial phase of anuria following incompatible blood transfusion for the removal of free hæmoglobin, hæmolytic toxins, and damaged erythrocytes. French surgeons prefer to withdraw the blood through a plastic tube inserted into the inferior vena cava (*Fig* 816). The amount of blood required to make exchange transfusion worth while for the removal of free hæmoglobin is equal to or twice, the volume of the patient's blood.

Fig 816.—Method of performing exchange transfusion in anuria. (*After P Millicz et al.*)

Much work has been done in France and Italy on exchange transfusions in uræmic states. The technique differs from small venesection and transfusions, to continuous exchange Nevertheless, exchange transfusion or for that matter any form of blood transfusion carried out in the oligæmic state carries serious disadvantages —

1 Excessive variations in blood volume are liable to lead to shock.

2. Transfusion reactions are more liable to occur than in other conditions.

3. There is a smaller removal of diffusible toxic substances than with dialysis.

The advantage of exchange transfusion is its simplicity as compared with dialysis.

Transperitoneal Dialysis.—Excellent clinical results in seriously ill patients have been reported, and the prime advantage of lavage is that little special equipment is required. The chief indications are : (1) When conservative treatment has failed to control progressive hyperpotassæmia (2) When the symptoms and signs of advancing uræmia (blood urea over 200 mg per cent) develop in spite of conservative measures—in these circumstances the possibility of recovery by conservative measures becomes less than the risk of resorting to extra renal means of excretion (3) Acidæmia severe enough to produce clinical symptoms.

Contra-indications (1) Recent abdominal operation (2) Infection of the skin of the anterior abdominal wall (3) Probable extensive intra-abdominal adhesions from a previous operation (4) Pronounced obesity and (5) Profound paralytic ileus.

Armamentarium consists of flasks containing the irrigating fluid (these preferably contain 2 L, and 15 flasks should be made up), an ordinary intravenous infusion set a

cannula with two trocars (one sharp and the other blunt these should be 20 cm. in length and the cannula should have an outside diameter of 2·5 mm.), two plastic tubes 12 in. (30 cm.) in length with an external diameter that will permit them to be inserted through the cannula; eight to ten small holes should be made in the distal part of each tube. Tubes of polyvinyl chloride which can be autoclaved, are to be preferred. These can be hardened to the desired stiffness (and they must be stiff enough to permit insertion without kinking) by immersion in mineral oil that has been heated almost to boiling-point. Two metal adaptors serve to connect the plastic tubes to the intravenous infusion apparatus on the one side and the exit tube on the other

Composition of the Irrigating Fluid.—The ideal fluid should be (1) Non-irritating to the peritoneum (2) Moderately hypertonic (3) It should permit maximum diffusion into it of nitrogenous and other waste products of a crystalloid nature.

Kolff's solution —

NaCl	6·0 G per litre	$MgCl_2$ (anhydrous)	0·1 G per litre
KCl	0·2 G "	NaH_2PO_4	0·05 G. "
$CaCl_2$ (anhydrous)	0·1 G	$NaHCO_3$	8·0 G. " "
Dextrose	20·0 G per litre		

Oxytetracycline (terramycin) 250 mg per litre is added before administration, to inhibit bacterial growth of any contamination of the fluid.

Technique.—Before proceeding a plain film of the abdomen, taken after an enema has been given, should be examined in order to visualize bowel filled with gas or faeces. The patient is prepared suitably with a sedative. He should lie flat on his back with the head and shoulders supported by a pillow The skin is prepared as for laparotomy and a point in the left iliac fossa comparable with that of McBurney s point on the right side is infiltrated with 1 per cent procaine. It is advisable to insert the first tube on the left side to avoid the possibility of entering the distended, relatively immobile, caecum. A small incision is made. The cannula, with the sharp trocar in place, is directed through the subcutaneous tissues, then, with a sharp thrust, the external oblique is penetrated. At this juncture the sharp trocar is replaced by the blunt one, and the remaining muscle and the peritoneum are traversed with another firm thrust. The trocar is removed and the plastic tube is inserted through the cannula into the peritoneal cavity for a distance of 8 in. (20 cm.). The cannula is then removed. The tube is connected to the intravenous set containing the irrigating fluid which has been warmed to body temperature The tube is strapped to the abdominal wall by adhesive plaster and covered with a sterile towel. The flow of fluid into the peritoneal cavity is then regulated to an almost continuous stream. Forty five minutes later when distension dull to percussion is present, the outflow tube is inserted on the right side, using the same technique This tube is connected to a rubber tube that leads into a collecting flask on the floor (*Fig* 817) It is essential that the rate of inflow be regulated to that of the outflow and optimum results are obtained with a flow maintained at between 2–3 litres per hour The flow should be continued for 12–15 hours. At the end of the procedure the inflow tube is removed. Moderate abdominal pressure helps to remove some of the fluid through the outflow tube; the outflow tube is then removed. In spite of this, approximately 1000 ml. of fluid is left in the peritoneal cavity This residue must be accounted for in the estimations of the fluid requirements during the 36 hours following the dialysis. The irrigation can be repeated in 48 hours without harm.

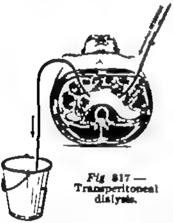

Fig 817 — Transperitoneal dialysis.

Difficulties —Change of position of the tubes, or reversing the direction of the flow often help to overcome difficulties in maintaining an adequate flow If the abdomen is allowed to become overdistended with fluid pain will occur In a French series only 3 of 100 patients treated by this method gave evidence of infection.

The Artificial Kidney —It is necessary to have a trained team to operate the artificial kidney Such a team is usually under the charge of a physician. As the apparatus and the trained team are only available in a few centres, this method will not be described here

COMPLICATIONS OF RENAL ANURIA

Overhydration.—If by some mischance the anuric patient becomes grossly over hydrated, immediate venesection is sometimes a life-saving procedure (see p 608). During venesection the blood pressure must be taken. The withdrawal of 300–500 ml. of blood is sometimes sufficient. The blood should be withdrawn into 3 8 per cent citrate solution so that if the patient is anæmic the erythrocytes, after sedimentation can be retransfused

In patients with anuria who have received already more than the basic allowance of fluid which often appertains in cases secondary to shock, no fluid should be given parenterally and virtually no fluid by mouth for 24 hours

Acidæmia.—It is undesirable to allow acidæmia to reach a level sufficient to increase the depth and rate of respirations. When the carbon-dioxide-combining power has fallen below 35 volumes per cent, 4–6 G of sodium bicarbonate can be given by mouth in divided doses of 1 G per hour Alternatively 3 75 G of sodium bicarbonate can be added to the 500 ml. daily allowance of dextrose solution for intravenous administration, or possibly better is it to employ an isotonic solution of sodium lactate (18 7 G per litre).[1]

Hyperpotassæmia.—When the need for reducing the serum potassium level is not a matter of great urgency a new treatment of considerable promise is the administration of sodium cycle resin.[2] In the alimentary canal the sodium ions of the resin are exchanged for those of potassium in the blood (*Fig* 818). Fairly prompt lowering of the plasma potassium has resulted from the administration orally or by nasogastric tube of 30–60 G of sodium cycle resin per 24 hours the approximate uptake of potassium is 1 mEq per G of resin. It has been found that the best method of administering the resin, which is unpalatable is by giving small doses of 5 G eight to twelve times a day The resin is suspended in water containing ice chips, and lactose or sucrose is added as well as artificial flavouring (B L. Martz) Chlorpromazine is very helpful in aiding the control of nausea during the treatment. A vegetable laxative must be given in conjunction with this treatment, otherwise the resin tends to cause fæcal impaction.

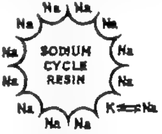

Fig 818.—Mode of action of sodium cycle resin.

Only very exceptionally does the released sodium cause hypernatræmia this can be corrected by the prompt administration of hydrogen cycle resin.

When reduction of the serum potassium is a very urgent matter (above 7 mEq per litre), or when the resin is vomited, recourse must be made to exchange transfusion or dialysis.

When the serum potassium level rises above 7 mEq per litre one of the more radical methods of removing the excess of potassium is indicated (see p. 601)

Cardiac Dysfunction is the most serious complication of acute renal failure, and is the principal cause of death There are two forms of cardiac dysfunction. The first and most common culminates in pulmonary œdema. The second is associated with hyper potassæmia. Heart failure with pulmonary œdema is treated by opiates, phlebotomy oxygen, or dialysis. Diuretics are contra indicated digitalis has a limited value.

Infection.—The cardinal importance of endeavouring to prevent, and to treat early infections, which are so prone to occur has been emphasized already

Vomiting.—While of course vomiting should be forestalled by gastric aspiration if aspirate continues to be plentiful after the intake is entirely intravenous, an attempt to determine its chemical basis, e.g cellular overhydration, and to correct it should be made. Sometimes no obvious cause can be found. In these circumstances chlorpromazine in doses of 25–50 mg three times daily by injection, is moderately effective. Given to a uræmic patient, chlorpromazine leads to a state close to hibernation. Doctors unaware of this may think, erroneously that the patient is moribund.

Abdominal Distension is a frequent and troublesome complication particularly if attempts are made to feed the patient. If it becomes excessive and only then gastro-intestinal aspiration is required, and the amount of fluid removed must be replaced intra venously

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[1] Sterivac (Allen & Hanburys) No. 12 solution.
[2] Eli Lilly & Co. Ltd., Basingstoke Hants.

Anæmia.—The severity of the anæmia parallels that of the azotæmia, as shown by the blood-urea. However once it becomes moderately severe, its progression slows or stops, even though the oliguria continues. It is striking how well severe anæmia is tolerated in the oliguric period, and although it may be responsible for some signs of cardiac dysfunction, one should be diffident about remedying it, because blood transfusion is so often followed by pulmonary congestion, indicative of cardiac failure. In cases where the hæmoglobin becomes very low and especially in the diuretic phase, the hæmoglobin level should be kept above 70 per cent by means of transfusion, always employing packed red cells (see p. 51).

Diarrhœa is sometimes very troublesome. If it does not improve after the administration of 0 25 G of erythromycin twice daily by mouth, all feeding must be stopped in favour of the administration of the necessary fluid, carbohydrate, and possibly electrolytes intravenously

Epistaxis.—The danger of epistaxis in a semi-comatosed patient in a recumbent position is not realized sufficiently for the blood is liable to be inspired. A bleeding nose must be packed securely If blood is inspired endotracheal suction, unless performed very early is unlikely to remove clotted blood. Tracheostomy and suction offer a better prospect.

Stomatitis is common in severe cases. Frequent mouth-washes and sucking bradosol lozenges usually keep it under control.

Purpura is common in the terminal uræmic state. There is no specific treatment

Pericarditis also occurs in terminal renal failure A watch must be kept for a pericardial effusion.

SPECIAL FORMS OF RENAL ANURIA

Anuria due to Incompatible Blood Transfusion.—(*See* p. 68).

Anuria due to Concealed Accidental Uterine Hæmorrhage is caused by combined hypotension and a temporary intense spasm of the cortical arteries. The areas of renal cortical necrosis are lost irretrievably consequently this results in acute progressive unrelenting renal failure.

Anuria due to Abortion.—It is not quite clear how abortion gives rise to intravascular hæmolysis the most probable explanation is an infection by *Cl. welchii* or the accidental injection of soap solution into the blood-stream by way of the uterine sinuses (H L. Sheehan)

Reflex Anuria.—A minority doubt the existence of this phenomenon and suggest that so-called reflex anuria following rapid emptying of an overdistended bladder is due to infection. The rapidity with which anuria sometimes follows this happening (*see* p. 651) would appear to put this theory out of court. Reflex anuria occasionally and unexpectedly follows the passage of a cystoscope or other instrument.

Margraves and Bogen's Case.—Following cystoscopy a man aged 29 developed anuria. After 66 hours of complete suppression of urine, he was given a spinal anæsthetic Within fifteen minutes this was followed by copious diuresis.

Because of the danger of anuria, C. P Mathé advises an interval of at least three days between intravenous and retrograde pyelography On rare occasions reflex anuria supervenes after nephrectomy —

A woman aged 42 had right nephrectomy performed for extensive calculus formation Previously the left kidney had been shown to be perfectly healthy by chromocystoscopy ureteric catheterization, and pyelography Thirty-six hours later she had passed no urine, and the bladder was empty Her general condition was excellent. Twenty four hours later only 1½ oz. (45 ml. of urine had been passed, and a further 2 oz. (60 ml.) was retrieved by catheterization. Twelve hours later the blood-urea had risen to 123 mg. and the patient began to vomit. The left ureter was catheterized without the difficulty that would be expected if it were obstructed, and urine commenced to drip steadily from the left kidney The catheter was left in place for 30 hours after which the patient's progress was straightforward.

Anuria due to Acute Pancreatitis.—The renal lesion is at least partly due to fat embolism as a sequel of fat necrosis. Oliguria is more common than complete anuria. Even after clinical recovery renal interstitial fibrosis usually follows.

Traumatic Anuria occurred frequently among air raid victims when a limb (or limbs was crushed beneath fallen masonry (the crush syndrome). It also occurred in battle casualties as a result of severe muscle damage and general tissue catabolism. The

phenomenon occurs, though less often, in severe crushing injuries of civil life. Unless treated expeditiously and correctly the mortality is very high death from uræmia on the seventh or eighth day being singularly constant.

The kidneys in crush syndrome are large and pale Microscopically the collecting tubules reveal degenerate epithelium and their lumina are packed with the debris of red corpuscles.

In cases of the crush syndrome an Esmarch's, or an elastic web bandage should be applied to the limb directly after the victim's extrication, the better to prevent the mass release of toxins. If the limb is spared amputation the bandage should be loosened inch by inch after a lumbar sympathetic block.

Technique of Lumbar Sympathetic Block.—For the unilateral block, three lumbar puncture needles are required for bilateral block, six. The interspaces between L. 1 2, and 3 are located, and at a point two fingerbreadths lateral to the middle line a weal of 1 per cent procaine is raised. When all the intradermic weals have been made the lumbar puncture needle is introduced through the weal and pressed straight down until it hits the transverse process. The depth at which this occurs is noted on the shaft of the needle the needle is then almost withdrawn. The needle is then tilted, so that its point will pass more towards the head of the patient, the objective being to introduce the point of the needle just above the transverse process. The needle, thus tilted, is reintroduced to the previously noted depth, and to this is added 2 cm. In muscular individuals it may be necessary to advance the point of the needle a little more. If the correct plane has been reached, injection of fluid is easy and nearly free from resistance. If the fluid does not enter readily it is being injected into muscle, and the needle should be advanced a little more and the injection tried again. Before each injection, aspiration should be attempted to make certain the point of the needle is not within the lumen of a blood-vessel. One ml. of 1 per cent procaine should be injected into each interspace.

While the treatment of traumatic anuria does not differ in principle from that of other forms of renal anuria, the frequency and rapidity of potassium intoxication constitutes the most important difference between traumatic anuria and the more usual forms of acute renal failure seen in civilian practice. Meroney and Herndon, after a considerable experience of this type of injury in the Korean War recommend the daily intravenous administration of 850 ml. of water containing 100 G of dextrose 8 73 G of sodium bicarbonate, and 10 G of calcium gluconate, together with 50 units of insulin. Both sodium and calcium are antagonistic to potassium, while the dextrose and insulin encourage potassium to re-enter the cells. Electrocardiographic control was particularly helpful in following the effects of this treatment in cases complicated by hyperpotassæmia.

Other military surgeons have found that in severe hyperpotassæmia dialysis with an artificial kidney is the best and, indeed in the case of a patient with an abdominal wound, the only method of reducing the plasma-potassium level.

Excision of necrotic tissue and drainage of accumulations of blood, if present, are imperative.

The tendency of œdema of the wound and delayed healing caused by high serum potassium level necessitates precautions being taken in the case of abdominal wounds to avoid burst abdomen.

OBSTRUCTIVE ANURIA

Calculous Anuria usually supervenes in one of the following ways: (1) Both ureters become blocked with stones (2) A calculus becomes impacted in the ureter of a sole existing kidney the other kidney being congenitally absent, previously removed or destroyed by disease.

As is well known, there is a period of tolerance during which the patient, although in fairly good condition, passes no urine I watched a boy of fourteen, who had had nephrectomy performed (for injury) upon what proved to be his only kidney live fourteen-and-a half days. Do not let this very variable period of tolerance deceive you into temporizing and wasting time no one can tell how long the period of tolerance will last; it may be but a few hours.

The patient is seen during the period of tolerance

1 *Distend the bladder* with warm lotion, which stimulates the ureter to contract and occasionally results in the passage of a ureteric calculus.

2. *Radiography* If facilities exist a radiograph is taken. In only three instances were stones demonstrable in a series of seven cases of calculous anuria (Cahill and Gile). Gaseous distension of the intestine no doubt accounts for this surprisingly large percentage of negative X ray findings. On no account should excretory pyelography be attempted.

3. *Cystoscopy* As soon as possible cystoscopy should be carried out under local anaesthesia œdema of, or a hæmorrhagic exudate from, one ureteric orifice will indicate the side that requires immediate relief. When a ureteric catheter can be made to pass up a ureter but no urine passes down its lumen, it suggests that the obstruction must be near the kidney Sometimes a ureteric catheter can be made to pass alongside a stone blocking the ureter in which case pent up urine drips through the catheter's lumen almost at once. In this happy event, the catheter should be left in position for as long as it continues to function and the longer the better A steady drip of urine through a ureteric catheter is sufficient to tide the patient over his desperate condition while further and better investigations are being carried out. In other circumstances, very early operation is indicated.

4 *Deciding upon which side to operate* A good rule is—select the side on which the patient last experienced pain. *Signe de Leguen* Muscular resistance is greater over the kidney last to be obstructed. Such resistance is demonstrable on abdominal palpation.

5. *Operation* The simplest operation that will relieve the obstruction is the one of choice Pyelostomy (*see* p. 621) fulfils these requirements. Nothing more should be attempted unless the stone causing obstruction is felt and seen in the renal pelvis or the commencement of the ureter when it should be removed by incising the wall over the stone. In some circumstances nephrostomy notably when the pelvis of the kidney is intra renal (*see Fig* 839 p 621), will be indicated.

6. *After-treatment* Those in attendance should disabuse their minds of the idea that because an operation has been performed their labours on behalf of the patient can be reduced. On the contrary constant care considerable skill and as likely as not visits during the night will be required. The amount of urine excreted within 8 hours of relieving the obstruction is, as a rule, disappointing When the obstruction is relieved during the period of tolerance, in order to kindle renal activity the very slow administration of 10 per cent dextrose solution (or an isotonic solution of sodium sulphate) is given intravenously If after the gravitation of half a pint (0·28 L) there is not a satisfactory output of urine *the infusion should be discontinued.* In any case only one pint should be given until the surgeon has seen the patient himself and in the meantime not more than a litre of fluid plus an amount equal to the quantity of urine passed per 24 hours is allowed by mouth. When the output of urine at the end of 24 hours is unsatisfactory or before that time if the patient has symptoms of uræmia, the régime of restricted fluids detailed on page 399 must be instituted.

When nephrostomy (as opposed to pyelostomy) has been necessary it is most important to be prepared for post-operative hæmorrhage, and it is a good practice in all cases to make full arrangements for blood transfusion, in case bleeding from the incised kidney becomes excessive

Calculus Obstructing the Outflow of a Single Functioning Kidney—

Case 1 —A woman of 45 had passed no urine for forty-eight hours. A catheter was introduced, but not a drop of urine was withdrawn. Four years previously her right kidney had been removed for calculous pyonephrosis. She was now experiencing violent pain in her left side The patient was extremely obese and a radiograph was not helpful.

The bladder was distended with lotion. The patient gave a piercing shriek, followed by a sigh of relief. A calculus about the size of a date stone was forcibly discharged with the lotion from the bladder

The same patient was readmitted one year later This time she had passed no urine for nearly three days. The bladder was empty Vesical distension was of no avail. By cystoscopy a ureteric catheter was passed freely up the left ureter which indicated that the obstruction was near the pelvis of the kidney Under general anaesthesia supplemented by local infiltration of procaine the kidney was exposed in the loin. Owing to the great obesity of the patient it was necessary to resect the last rib before the organ could be displayed. A calculus was felt in the first inch of the ureter This was pushed up into the renal pelvis by digital pressure. The renal pedicle was short and the renal pelvis mainly intrarenal. Pyelostomy was therefore impracticable. Nephrostomy was performed and the stone was removed. Owing to the friability of the œdematous kidney sutures on either side of the tube cut out, but this difficulty was overcome and the resulting

hæmorrhage checked by inserting fresh sutures over a muscle graft taken from the sacrospinalis. Recovery She wore a nephrostomy belt (*Fig* 819) which was efficient. Eight and a half years later her doctor reported to me her death from bronchopneumonia. During the interval she had attended to the nephrostomy herself, and went about her household duties

Case 2.—W H. A., aged 43 had an attack of typical right renal colic lasting about an hour; never before had he experienced symptoms of this character The following day he remembered that he had not passed urine since the attack but because the pain had practically disappeared he "took no notice" So drew to a close the second the third, and fourth days. Neither a drop of urine did he pass nor he stated, were his bowels open. On the fifth day it dawned upon him that he should consult his doctor who sent him to hospital as quickly as possible

Except that the patient was mentally sluggish and his bladder was completely empty there was nothing abnormal to be made out upon a clinical examination, but his blood-urea estimation registered no less than 253 mg per cent. As so often happens in these cases, a plain radiograph showed no abnormality save excessive intestinal gas. Cystoscopy revealed only one ureteric orifice—the right A ureteric catheter was passed and about 3 in. (7 5 cm.) from the ureteric orifice it met with obstruction. The catheter was partially withdrawn, and advanced once more, and to my delight dark blood-stained urine commenced to drip through the catheter For five hours dark blood-stained urine dripped steadily through the ureteric catheter At 2 a.m. the catheter became blocked, and was removed. The next morning, as he had not passed urine a urethral catheter was passed and 20 oz. (568 ml.) of very blood-stained urine containing clot was withdrawn. In spite of irrigations, the catheter became blocked with blood clot; therefore it was changed, but only 5 oz. of urine was withdrawn and this was all that was registered as being excreted during the course of the day It was considered that the patient's only chance was to operate He was very befogged mentally and somewhat irrational.

Fig 819—Permanent nephrostomy The nephrostomy tube is kept in place by a tape around the waist. (*After M L. Boyd.*)

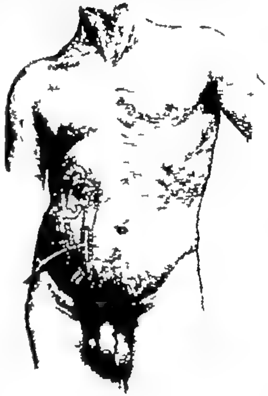

Fig 820—Kidd's oblique incision for exposing the ureter Like a long gridiron incision the main difference is that the fibres of the internal oblique are severed, not split. The peritoneum having been displayed, it is pushed medially until the ureter is reached

Right nephrostomy was contemplated, but the patient was a subject with advanced scoliosis, which reduced the space between the last rib and the iliac crest to about 3 in. (7 5 cm.); consequently it was decided to approach the right ureter through an anterior incision. Under *local anæsthesia* the ureter was exposed extraperitoneally through a Kidd's oblique incision (*Fig* 820). The ureter was about the diameter of a thumb. A longitudinal incision was made into it and uriniferous fluid and blood-clot were extruded. A large T-tube was fixed in place. After corrugated rubber drainage had been provided the abdominal wall was closed about the T tube. The cautious administration of 10 per cent dextrose solution intravenously was ordered. The blood-urea estimation on this day registered 212 mg. per cent.

Thirty-six hours later to my dismay I found the patient in deep coma with Cheyne-Stokes respirations. His face was cyanotic and suffused. To my consternation I learned that in spite of the fact that no urine had issued from the T-tube and that the dressings were doubtfully damp,

the intravenous drip had been continued and that the patient had received no less than 4 pt. (2·3 l.) of fluid intravenously. I then learned that the House Surgeon had gone away for the week-end without turning the case over to anyone else, and by one of those unfortunate coincidences, it was also the Sister's week-end off duty and the usual staff nurse was ill.

In view of the desperate situation, a cannula was inserted into the patient's jugular vein. Black blood issued therefrom and as it flowed into a dish, the shimmer of cholesterol could be seen on the surface. After a pint had thus been withdrawn, the patient's respirations seemed to become more quiet and his face was less suffused. Another pint was allowed to flow out while plasma was gravitated into the median basilic vein on the other side. Thus two pints of blood were removed and one pint of plasma was given.

Forty-eight hours after the venesection, urine commenced to drain through the T-tube. Therefore intravenous fluid therapy was recommenced. Within half an hour the amount of urine issuing from the tube became perceptibly greater and during the next twelve hours he passed no less than 130 oz. (3·7 l.) of urine.

Never before have I seen such a quick resurrection from a seemingly hopeless uræmic state. Twenty-four hours later the patient's mentality had cleared completely, his tongue was moist, he said he was hungry, and his blood-urea was now 84 per cent.

A week later, as the patient was passing urine per urethram, the T-tube was removed. An intravenous pyelogram showed no evidence of a functioning left kidney. Re-cystoscopy confirmed the absence of a left ureteric orifice, so this was an undoubted example of congenital absence of the left kidney and ureter. A retrograde pyelogram at this time showed an unobstructed ureter and dilated calices. Five years later he was in good health and at work. The obstructing calculus, which undoubtedly was present, was never retrieved.

Anuria due to Double Hydronephrosis.—Occasionally bilateral obstruction to the pelvi-ureteric junction occurs.

I was called into the country to see M. G., aged 7. Five days previously her appendix had been removed for right-sided abdominal pain. The appendix, her doctor stated, was comparatively normal. Since the operation not a drop of urine had been passed. The patient, although fretful, appeared in excellent condition. She was anæsthetized and the left ureter was catheterized. Almost immediately urine dripped through the catheter in a rapid succession of drops. The right ureter was then catheterized, and although the catheter passed up the ureter well, no urine could be obtained from this side. Leaving the catheters in position, the patient was turned on to her face, and the right kidney was exposed. The pelvi-ureteric junction was obstructed by an aberrant renal vein. The pelvis of the kidney was greatly distended and below the obstruction the tip of the ureteric catheter could be felt. The vein was divided between ligatures, and the pelvi-ureteric junction was cleared of some fine fibrous strands which were compressing it. By this time the ureteric catheter had slipped down the ureter somewhat, so the operation was concluded by performing pyelostomy.

A year later the patient returned, having had an attack of pain on the left side. Excretory pyelography showed that the right kidney was functioning well, while the left showed a pelvic hydronephrosis. At operation an aberrant renal vein was found in exactly the same position as on the right side. It was divided between ligatures.

Twelve years later the patient was in perfect health.

More often anuria due to double hydronephrosis is caused by carcinoma of the cervix uteri, in which case immediate unilateral or bilateral nephrostomy is usually advised. Ureterostomy, as described and illustrated on p. 607, might prove to be a more desirable alternative. Simultaneous occlusion of both ureters by metastatic carcinomata is not very uncommon.

Anuria following Pelvic Operations, Notably Hysterectomy.—(See p. 592).

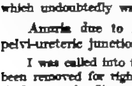

Fig. 821.—Acetylated sulphapyridine crystals resemble small wheat sheafs. (*After E. S. Margolin.*)

Anuria due to Sulphonamide Crystalluria.—Owing to the comparative infrequency of the use of sulphonamides since the antibiotic era, anuria from sulphonamide crystalluria is now very uncommon. Orientals appear to be more susceptible to sulphonamide crystalluria than white races. Sulphapyridine and sulphathiazole in the presence of an acid medium are changed into acetyl salts which are insoluble and are sharp, long crystals (*Fig.* 821), such crystals being deposited in the kidney tubules or the ureters. Sulphapyridine gravel is most in evidence in the lower third of the ureter. The renal complications of sulphonamide therapy can be divided into three stages: (1) Microscopical hæmaturia. (2) Macroscopical hæmaturia, usually painful. (3) Oliguria and anuria.

Treatment.—As in the case of calculous anuria the bladder should be distended with warm saline solution, and it is desirable to repeat the procedure two or three times. Firm,

deep massage is then carried out upon each kidney The lower end of each ureter is then massaged by way of the rectum or the vagina, preferably with the patient in the knee-elbow position. By these expedients the crystals may be dislodged sufficiently to re-establish a small flow of sludge-like urine When external manipulative measures fail to unblock the ureters, the sooner cystoscopy is performed the better Bladder irrigations will help to dissolve the crystals and wash them away from the trigone and so the ureteric orifices can be seen. If it has not been left too late ureteric catheterization is a life-saving measure in this form of anuria. Provided the catheters can be inserted, the kidney pelves are washed out with 2 5 per cent sodium bicarbonate solution Surgeons familiar with the use of the spiral ureteric calculus remover have used this successfully to disimpact sludge from the terminal portion of the ureter In most instances if the surgeon fails to pass the catheters, pyelostomy must be performed.

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CHAPTER LII

EMERGENCY OPERATIONS UPON THE KIDNEY

EXPOSURE OF THE KIDNEY BY THE LUMBAR ROUTE

Two incisions—Morris's and Mayo's—will be described the first is in comm I have found the second to have certain advantages, particularly in an emergency the renal fascia has been reached the steps in each operation are identical.

Morris's Incision.—

Position of the Patient is of the utmost importance Every detail of it sh supervised by the surgeon himself. The patient is placed on his sound side his l which the surgeon stands, being brought near to the edge of the table. The hip a of the leg next to the table are flexed fully and secured in this position either by a b sling (*Fig* 822) or by sandbags. This will counteract the tendency of the trunk in either direction. The kidney bridge the split in the operating table or falling an air cushion or sandbag must lie directly beneath the 11th rib so that when one

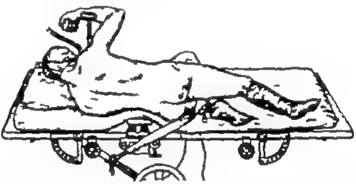

Fig 822.—Position of patient on the operating table for exposure of the kidney by Morris's incision (*After Eric Farquharson.*)

mechanical aids is brought into action, the space available for access to the flank is in considerably A support for the arm relieves pressure on the thorax, and helps to the patient in the desired position.

Technique.—Prior to making the incision, palpation of the vertebral column, t rib and the iliac crest helps to orientate the surgeon If a radiograph of the tract is available, it will reveal whether the patient has an unusually short 12th ri is likely to be impalpable should the 11th be mistaken for the 12th rib, the inci be made too high in which case almost certainly the pleura will be opened. The commences above the costovertebral angle it is carried downwards and forwards to and about ½ in. (1 3 cm) below the last rib for 10 to 12 inches (25 to 30 the direction of the anterior superior iliac spine Thus the incision has an upw at its posterior end the better to gain access to the base of the 12th rib. The in deepened to display the muscles. The first layer to be encountered is, in the up of the wound, the latissimus dorsi, which is severed in the line of the incision In th half of the wound the external oblique which is split in the direction of its fibr 823) Bleeding vessel are ligated The next muscular layer is that of the oblique which is divided almost across its fibres in the length of the incision. It is in this layer that the 12th dorsal nerve is encountered; it must be preserved ca and care taken that it is not clamped in the jaws of a hæmostat while picking up a b vessel It should be retracted downwards and laterally After further blood have been ligated and retractors placed under the edges of the wound the und transversus muscle will be exposed in the anterior part of the incision while pos

this layer gives place to the dorso-lumbar fascia. Both the fascia and the transversus are divided in the length of the incision. Beneath this layer lies the renal fascia (fascia of Zückerkandl), which surrounds the perirenal fat (*Fig* 824) Further steps of the operation are described below under the heading Mobilization of the kidney

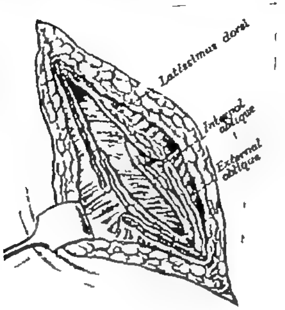

Fig 823.—The muscles have been divided, and the transversalis fascia bulges into the wound. (*After A I Dodson.*)

If more room is required the tense edge of the ligamentous attachment between the last rib and the transverse process of the first lumbar vertebra can be severed. Often this results in brisk hæmorrhage from the 12th intercostal artery which must be ligated. A firm pull on the retractor around the upper lip of the incision causes the 12th rib to

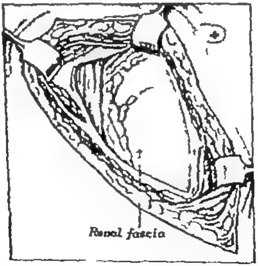

Fig 824 —The renal fascia exposed. (*After A I Dodson.*)

become dislocated in a young subject in an older subject, frequently the rib is fractured which causes no untoward symptoms. In either event, much room is gained and the need for subperiosteal resection of the 12th rib is obviated.

Accidental opening of the pleura: Children excepted, rarely the pleura extends below the lower border of the 12th rib but one must always keep the pleura in mind when encroaching upon the costovertebral angle An opening in the pleura is recognised by a

sucking sound, which is comparatively faint when endotracheal anæsthesia is being employed. The opening should be occluded by the finger and as soon as possible it should be closed by interrupted sutures. When the last suture is being inserted the anæsthetist is requested to expand the lungs. When endotracheal anæsthesia is not being employed, and a considerable amount of air has been allowed to enter the pleural cavity it is best to insert a Jacques catheter of average size and aspirate the air before the final suture is tied. In either event a radiograph of the thorax should be taken at the earliest opportunity and if it reveals a significant amount of air in the pleural cavity the air should be aspirated through a hollow needle.

Mayo's Incision.—One of several advantages of Mayo's incision is that comparatively few blood vessels are encountered during the exposure of the kidney.

Position of Patient.—The prone position (*Fig.* 825) will be found most satisfactory. The position offers two advantages. Firstly the kidney can be exposed rapidly. Secondly

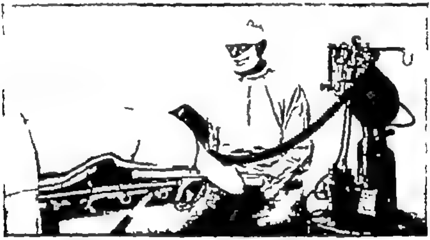

Fig. 825.—The prone position for exposing the kidney in the loin. Moderate elevation of the bridge of the operating table gives adequate flexion.

the opposite side is available immediately should it be necessary to explore the contralateral organ. When the time comes for closure of the wound the bridge of the table is lowered, or the bags are deflated.

Technique.—This incision commences over the centre of the sacrospinalis at the level of the upper border of the twelfth rib and passes directly downwards for 3 in. (7.5 cm.) where it curves outwards to form a J (*Figs.* 826, 827).

1. The sacrospinalis sheath is incised vertically and the sacrospinalis muscle is retracted medially.

2. The deep aspect of the sacrospinalis sheath is incised vertically.

3. The quadratus lumborum is retracted medially.

4. The extraperitoneal fat and peritoneum are pushed laterally.

The renal fascia (fascia of Zückerkandl) is now exposed. Usually the 12th dorsal nerve can be found coming from beneath the upper part of the quadratus lumborum, and coursing downwards and forwards: the nerve must be preserved carefully.

The subsequent steps of the operation are described below under the heading Mobilization of the Kidney.

If more room is required, ligaments uniting the 12th rib to the vertebræ are divided, and the 12th rib is pulled upwards. If still more room is needed, the 12th rib may be excised subperiosteally.

Mobilization of the Kidney.—In either of the incisions described when the renal fascia has been reached the next step is to make a short incision through this fascia. The posterior part of the incision is chosen for this purpose the better to avoid opening the peritoneum. The incision is enlarged by inserting the two index fingers and tearing open this fascial envelope thus exposing the perirenal fat. The fat is picked up in dissecting forceps, and by blunt dissection with a closed hæmostat, the jaws of which are opened if necessary, a portion of the renal capsule is displayed. By digital dissection the perirenal

fat is stripped from the kidney. In the course of this dissection a tight string-like structure is sometimes felt passing to the kidney in the region of the upper pole. This is probably an aberrant renal vessel, and it must be displayed to vision. Unless it proves to be an artery of considerable size it should be divided between hæmostats and its ends ligated.

Fig. 826.—Mayo incision for exposure of the kidney.

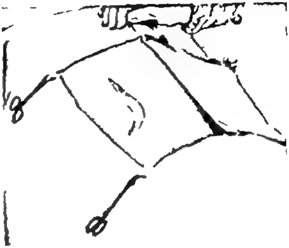

Fig. 827.—Mayo's incision. The sheath of the erector spinæ is about to be incised.

Although aberrant renal vessels passing to the lower pole are much more common than the foregoing, they course parallel to, and so near the renal pedicle that frequently they are not detected until the kidney has been delivered and its pedicle has been cleared of fat. Usually the perirenal fat can be separated from the renal capsule without difficulty. Anteriorly one must be mindful that on the right side the retroperitoneal portion of

Fig. 828.—Delivery of a kidney. The upper pole is delivered first; gauze packing is inserted into the wound to prevent this slipping back whilst the lower pole is delivered.

the duodenum overlying the inferior vena cava is in close relationship to the hilum of the kidney. Both these structures can be protected by packing the duodenum away from the field of operation. On the left side descending colon should be protected similarly.

Delivery of the Kidney (*Fig.* 828).—It is a great mistake to attempt to haul the organ out of the wound. The upper pole, after being freed from attachments, is brought to the surface. Gauze, still attached to a wide roll, is packed beneath the upper pole to keep it elevated, while the lower pole is delivered similarly. Always deliver the kidney one pole at a time.

The Kidney is too adherent to be mobilized in the usual manner When serious perirenal inflammation or previous operation or operations on the kidney have resulted in adherence of the capsule to surrounding tissues, mobilization of the kidney by blunt dissection is impossible or inadvisable. If these adhesions are capable of definition, the kidney should be separated from surrounding structures by meticulous sharp dissection, keeping close to the kidney first posteriorly then round the lower pole then round the upper pole, and finally anteriorly Should the kidney be found to be embedded in iron-like adhesions—a contingency that is not exceedingly rare—such a dissection if possible is dark, dangerous, and bloody Consequently in these circumstances, if the contralateral side is known to be healthy it is far better to decide to perform the operation of subcapsular nephrectomy (*see below*)

LUMBAR NEPHRECTOMY

Apart from irreparable rupture the indications for nephrectomy as an emergency procedure are few Without the advantage of having investigated the function of each kidney by refined methods, nephrectomy should seldom be even contemplated. Violent hæmaturia is sometimes an indication for fairly urgent nephrectomy but blood transfusion has rendered it possible to delay the operation until adequate investigation has been undertaken. If it is necessary to operate at short notice upon a pyonephrosis, nephrostomy should be performed. Failure to observe this general principle has led to disaster

Fig 829 —Nephrectomy The segmental division of the renal pedicle should be noted. This is much safer than mass ligature

Once the kidney has been delivered, its removal in cases of rupture is simple Working from below upwards, the individual constituents of the pedicle are clamped with ordinary long hæmostat and cut—a section at a time (*Fig* 829) The clamps may be placed quite close to the kidney This technique is far better than the mass ligature and makes slipping of the renal pedicle almost impossible

Subcapsular Nephrectomy which greatly reduces the possibility of injury to the duodenum, colon, spleen adrenal, or the pleura, is advised when the kidney is embedded in dense adhesions.

An incision is made through the thickened renal capsule along its convex border and with the finger a plane of cleavage will be found between the capsule and the parenchyma (*Fig* 830). Separation is carried out on each surface and around the poles. After freeing the kidney as far as the hilum, the capsule is again incised, this time circularly 1 cm. from the renal hilum This gives access to the renal pedicle which usually can be dealt with

in an orthodox fashion. When the pedicle is short and inaccessible instead of attempting to ligate it, the hæmostats can be left attached, as described on p. 610.

When the operator is fearful that if the decapsulated kidney is cut away the hæmostats might slide off the renal pedicle D. S. Vallett recommends and has practised successfully two-stage nephrectomy. *The forceps are left on and the wound is left open* and packed. Six days later the necrotic kidney is excised and the forceps are removed. *As a rule the wound can be closed without drainage.*

The Management of the Renal Pelvis in a Difficult Case of Nephrectomy.—*The kidney having been excised exceptionally because of shortness of the renal pedicle adhesions, obesity of the patient or his poor condition it may be considered unwise to attempt to ligate the renal pedicle.* In these circumstances the hæmostats on the renal pedicle are left in situ, and provision is made to protect them. Sufficient gauze is wrapped around the blades, as well as the shafts, of the hæmostats to keep them from coming into contact with the wound, which is approximated around them. J. T. Priestley recommends that the two protruding rings of each hæmostat be tied together with strong silk to prevent the hæmostat becoming loosened accidentally. All the hæmostats are then tied together by one encircling ligature around their shafts, just below the handles. After the wound has been dressed a protective covering is placed over the protruding handles. If a suitably sized firm cardboard box can be found the bottom is removed so that the intact sides can act as a rampart when placed over the handles and secured by adhesive plaster. *If no such box can be found,* gauze is wound around the handles and secured by a ligature. The patient is nursed on his side; when possible a special nurse should be in attendance. An appropriate sedative is given every four hours until the hæmostats are removed, which is commenced 72 hours after their application. The silk ligatures securing the handles and rings are cut, and the hæmostats are loosened one ratchet each. Priestley recommends an interval of 24 hours between the loosening and removal of the hæmostats. The gauze which was placed in the wound around the hæmostats is removed gradually during the next two or three days. *A solution of balsam of Peru will help to soften and loosen the gauze before it is withdrawn.*

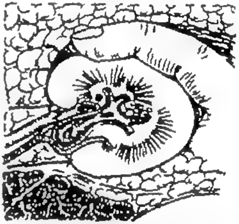

Fig. 630.—Subcapsular nephrectomy. The arrows indicate where circular division of the capsule must be made in order that the structures comprising the pedicle can be divided. (*After Eric Farquharson.*)

Severe Hæmorrhage during Nephrectomy.—

Slipped Renal Pedicle.—Mayo has immortalized the slipped renal pedicle, which, he said, "fairly jumps into the fingers" when nimble fingers promptly follow its retraction into the depths of the wound. It would seem that a potent cause of slipping of the pedicle is the use of a single, large, and consequently clumsy, clamp.

Two measures should not be attempted: (*a*) To apply hæmostats blindly—this is usually unsuccessful and on the right side the duodenum may be injured. (*b*) To rely solely on packing.

The immediate treatment is to control the hæmorrhage by digital compression. If after the hæmorrhage has been controlled temporarily in this manner one feels hampered for room in which to apply hæmostats accurately the incision should be enlarged by the assistant. If necessary one or even two ribs should be resected. With the surgeon's fingers still compressing the bleeding point, *retraction is so arranged that the fingers are seen before applying hæmostats.*

When the surgeon fails to grip the bleeding pedicle instantaneous packing and pressure of the pack against the vertebral column is fundamental. Pack follows pack in the manner about to be described, until the wound is filled. Then follows a difficult period of restraint—a wait of up to four or five minutes. Details of this and the subsequent steps will be described.

G. H. W., aged 54, was undergoing nephro-ureterectomy for a tuberculous kidney. The enormously thickened ureter had been divided between ligatures near the bladder through an anterior incision, and the lumbar stage of the operation was in progress. The kidney was a large

one—at least three times normal size. With difficulty (adhesions) the upper pole was delivered. It must be realized that the ureter having been disconnected from the bladder and mobilized, the only constituents of the pedicle still attaching the kidney were the renal vessels. Owing to adhesions, delivery of the lower pole was also difficult. As the lower pole was being firmly but gently lifted by the fingers beneath it, there was a sudden snap. The pyonephrosis fell and bounced on the floor. The terrifying hæmorrhagic cascade caused my left hand to obey reflexly Mayo's instructions, but on this occasion although the fingers grasped something, evidently it was not the entire renal pedicle. Therefore an abdominal pack was rammed as hard as possible into the depths of the wound, simultaneously letting go of what was grasped between the left finger and thumb. Keeping up compression of the pack against the vertebral column, a second pack was inserted, and pressure was applied by the left hand while the right hand was disengaged. Further packs were inserted with heavy compression, until the entire wound was filled. The patient's condition was not good but the anæsthetist reported that he could feel the pulse. The anæsthetist was requested to supervise the assembling of apparatus for a plasma infusion. Keeping up the compression for at least a minute, I pondered on the best course to adopt. Remembering that I had written in this book that in this predicament one must never rely upon packing, I removed the packs one by one, until the original pack alone was left. Removing this suddenly with my right hand I was enabled to see from whence the blood was issuing and to seize the remnant of the renal pedicle between my left forefinger and thumb. It was now a surprisingly simple matter to apply a long hæmostat accurately and this controlled all hæmorrhage. No attempt was made to apply a ligature as it was feared that it might cut out. The wound was quickly sutured with the handles of the hæmostat protruding. Gauze was then wrapped round the protruding part of the hæmostat so as to immobilize it. The patient was given a plasma infusion and later blood transfusion.

On the fourth day the ratchet was loosened, and three hours later the hæmostat was removed uneventfully. The patient was seen six months later and his condition was satisfactory.

A French surgeon wishing to demonstrate his method of dealing with hæmorrhage from the renal pedicle proceeded as follows: delivering the kidney into the lumbar wound, he deliberately severed the renal pedicle with a pair of scissors, without first applying either hæmostats or a ligature to the renal vessels. He immediately packed the wound tightly with abdominal packs. This accomplished, he removed his gloves and sat down and drank a cup of tea. Five minutes passed before he returned to his task. When the packs were gently removed the field remained dry long enough for him to apply with deliberation hæmostats to both the renal artery and vein. His secret of success lay in exercising restraint and in allowing sufficient time to elapse for the torrential hæmorrhage to be reduced by sustained pressure and reflex vasospasm (Sir Reginald Watson-Jones).

Injury of the Inferior Vena Cava during Right Nephrectomy.—The inferior vena cava has no valves. Half way to the heart it receives both renal veins. The left renal vein is longer and thicker than the right and enters the vena cava more proximally. This knowledge is fundamental if the vena cava has to be ligated, for after right nephrectomy life can only be maintained when the ligation is distal to the entrance of the left renal vein. The mortality from tearing the inferior vena cava during nephrectomy amounts to about 50 per cent. Death usually results from exsanguination, but occasionally from air embolism. The inferior vena cava is liable to injury by avulsion of the renal vein, almost invariably the right renal vein, from the caval wall. Occasionally the accident is due to an injudicious pull on the spermatic or ovarian vein.

The best immediate treatment is direct manual compression of the vena cava below the tear. If this can be accomplished, it is better than compression applied over an abdominal pack. The lumbar incision must be enlarged upwards and downwards, so that ample exposure is obtained. The compression of the vena cava is taken over by an assistant while the surgeon examines the extent of the damage. If the tear is small, direct suture is the right course. When the tear is more extensive, suture can still be carried out if the vena cava is occluded above and below by placing thin rubber tubing around the vessel and clamping it in a hæmostat. Alternatively, ligation of the vena cava as low as possible is the only course. The results following ligation of the inferior vena cava for this accident are fair. Although series with a lower mortality have been reported, F. Papin reported 6 deaths in 15 cases, which is about what can be expected of this measure in expert hands. Surprisingly, Boeminghaus, who has performed the operation repeatedly, states that he has seen no early or late ill-effects following ligation of the inferior vena cava. This is not the experience of others (see p. 920).

SEVERE HÆMORRHAGE AFTER NEPHRECTOMY

If bleeding occurs some hours after nephrectomy and continues in spite of morphine and blood transfusion—if matched blood can be obtained in time—the wound must be reopened and the bleeding point sought. Often it is impossible to locate the source of the hæmorrhage and recourse must be made to packing the wound with gauze. The portion of gauze which is first introduced may with advantage be absorbable gauze.

SEVERE HÆMORRHAGE AFTER NEPHROLITHOTOMY

The general principles in treatment are precisely similar to those of a severe injury to the kidney (see p. 583).

In my case index for June 1922, there is the following entry: "During this month I have seen three cases of severe hæmaturia following nephrolithotomy. In all of them the condition of the patient was alarming and did not respond to morphine. I remarked that these cases do not die." All recovered. A little more than two months later a fourth case came under my notice and it was not until the profoundly anæmic patient died on the eighth day that I lost faith in my new found aphorism. Two years intervened before another opportunity occurred of studying this condition.

L. F., aged 47, had left nephrolithotomy performed. By X rays a cluster of stones in the pelvis and lower pole of the left kidney had been shown. Three large branched calculi were extracted after splitting the kidney longitudinally. Fairly profuse hæmaturia persisted until the fifth day, but on the sixth day it appeared to be clearing and there was little to call attention to the patient until the morning of the twelfth day, when 10 oz. (0·3 l.) of almost pure blood were passed. On the three succeeding days the same thing occurred each morning, in spite of large doses of morphine. The general condition of the patient became alarming. The pulse rate was recorded hourly, and as this showed a steady increase, on the evening of the fifteenth day, with blood transfusion proceeding, left nephrectomy was performed. The perinephric space and the interior of the kidney were full of blood-clot. Drainage. Recovery.

Fig. 831 shows the specimen. The extensive anæmic infarction on either side of the longitudinal wound is good evidence that post mortem splitting of the kidney is a poor surgical procedure. An incision radiating from the hilum which more nearly follows the ramifications of the intrarenal vessels, is not open to this objection.

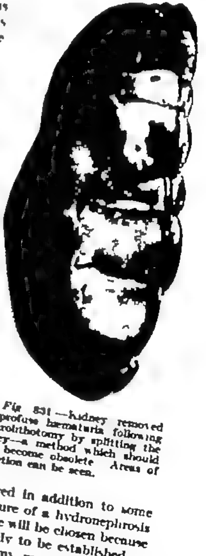

Fig. 831.—Kidney removed for profuse hæmaturia following nephrolithotomy by splitting the kidney—a method which should have become obsolete. Areas of infarction can be seen.

ABDOMINAL NEPHRECTOMY

The indications for abdominal nephrectomy are very limited indeed. It will be found of service in cases of intraperitoneal rupture of the kidney which are exceedingly rare and possibly when the kidney is found to be ruptured in addition to some intraperitoneal lesion. In such conditions as intra-abdominal rupture of a hydronephrosis and torsion of the pedicle of an ectopic kidney, the abdominal route will be chosen because until the abdomen has been opened the correct diagnosis is unlikely to be established.

In torrential hæmaturia of renal origin abdominal nephrectomy may sometimes be resorted to, as was done in the following case:—

A. W., aged 50, gave the following history. Eighteen years previously she had a cyst removed from the right kidney. Four years afterwards the same kidney had been fixed. For the past three years attacks of painless hæmaturia had occurred, but during the past six weeks the bleeding had occurred daily. During the four days immediately preceding, the doctor in attendance stated that pure blood had been running away "like a tap." The patient was quite blanched, complained of singing in her ears, and seemed wandering in her statements. The pulse was very feeble and all that could be found on physical examination was the scar of previous operations in the right loin. Blood transfusion was carried out the same evening. On the following morning

her general condition had improved somewhat but the urine was full of blood. Under a general anæsthetic after repeated washings, cystoscopy showed a blood-clot in the orifice of the right ureter. The abdomen was opened by a right rectus incision, which was in turn converted into a Rutherford Morison's incision by a transverse cut outwards. The right kidney was ill-formed and adherent. The left kidney felt normal. Abdominal nephrectomy. Recovery. The patient was alive and well two years later. Serial sections of the kidney failed to reveal the cause of the hæmorrhage.

The reason for choosing the abdominal route in this case was the fact that the patient had had two previous operations on the kidney that was bleeding and it was considered the scar tissue would render a lumbar exploration exceedingly difficult.

Fig. 832.—Incision for abdominal nephrectomy. If more room is required, the transverse extension is made.

An advantage of abdominal nephrectomy is that it permits examination by palpation of the opposite kidney. It is, however, a dangerous route to traverse if there is any question of the lesion being inflammatory. The operation is distinctly difficult in the presence of meteorism, or when the anæsthetic has not rendered the abdominal wall flaccid. Abdominal nephrectomy can be carried out through an incision similar to Battle's incision, though placed higher (*Fig.* 832). The incision must be of ample proportions, and if it is found that more room is required a transverse cut can be made towards the flank (*Fig.* 832). The peritoneum having been opened, the intestines are packed off carefully. The posterior layer of the peritoneum is now incised on the lateral side of the colon. It is highly important to be absolutely certain that this incision is made on the *outer* side of the large intestine, otherwise the blood supply to that part of the colon will be jeopardized. By gauze dissection the colon and its mesentery are mobilized towards the middle line. The kidney is now accessible. The renal pedicle is ligated in sections. After the kidney has been removed, usually it is a wise precaution to drain the perirenal space through a stab incision in the loin. The peritoneum of the posterior abdominal wall is then closed and the anterior abdominal incision repaired in the usual manner.

Torsion of an Ectopic Kidney.—Abdominal nephrectomy has to be performed occasionally as an emergency for torsion of a mal-placed organ, of which the following is a good example.

H. N., aged 17, was admitted to hospital at 3 a.m. one autumn morning. He gave a history of a sudden onset of abdominal pain thirty-six hours previously. The pain *began* in the right side. He had vomited four times. The pulse was 104 and the temperature 99° F. (37.2° C.). There was rigidity, tenderness, and hyperæsthesia in the right iliac fossa. A diagnosis of acute appendicitis was made, but as the pain had *begun* in the right iliac fossa, it was mentally noted that this was the only unusual feature in an otherwise typical case. The urine was normal. At 8 a.m. he was anæsthetized. Under the anæsthetic a large lump could be felt in the right iliac fossa, which, it was thought, might be an appendix abscess. Gridiron incision showed a round, purple retroperitoneal swelling about the size of a tangerine. The incision was enlarged downwards by detaching the internal oblique from the rectus sheath. A hand was passed into the abdomen, and it was noted that the right kidney was absent from its normal position, whereas the left kidney was large and normally placed. The lump was therefore the (small) right kidney. The intestines were packed off medially and the cæcum was mobilized a little and then packed away into the

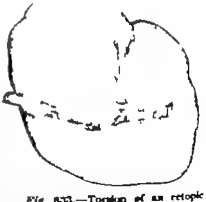

Fig. 833.—Torsion of an ectopic kidney. Drawing of a specimen removed at operation. Note the ureter on the left and the twisted renal vessels on the right.

upper part of the wound. The peritoneum was incised over the swelling, and a very deformed rounded kidney delivered the pelvis of which was extremely dilated (Fig 833). A twist was noted in the ureter and on turning the kidney through a complete clockwise circle the ureter straightened out and the tense pelvis discharged its contents into the bladder The ureter was so short that there was no hope of placing the organ in the loin, so nephrectomy was performed by dividing the ureter between clamps and likewise the renal vessels, which entered at the upper pole diametrically opposite the ureter The peritoneum of the posterior abdominal wall was then brought together and the abdomen closed Recovery

NEPHROSTOMY

Nephrostomy is an excellent emergency measure in several conditions, notably —

1 For the relief of obstructive anuria due for example, to bilateral ureteric calculi or to a calculus occluding the ureter of an only functional kidney (see p 600)

2. To divert the urinary stream in accidental ligation or severance of a ureter or ureters (see p. 302)

3. To drain a pyonephrosis.

4 As an accessory measure after suture of a lacerated kidney (see p 300)

The exposure of the kidney is carried out in exactly the same manner as described on p 610 Usually the incision should be a large one because the kidney is likely to be engorged, probably in part hydronephrotic and sometimes full of pus. Three methods of performing nephrostomy will be described each having its special use.

Certain features are common to all methods any type of catheter with an expanded end is likely to produce undesirable pressure on the renal parenchyma. The best drain for the interior of a kidney is a fairly large whistle-tipped catheter (Fig 834) Once in

Fig 834 —Whistle-tipped catheter

place (its tip should lie in or near the lowest calix) the tube should be anchored to the kidney by a chromic catgut stitch which transfixes the capsule, a small amount of parenchyma, and a segment of the diameter of the tube. While such a suture will not stand much strain, it helps to hold the catheter in the desired position In the absence of a whistle-tipped catheter a piece of rubber tubing can be cut similarly Polythene tubing has an advantage in that it has less tendency to become occluded by the precipitation of crystalline material from the urine A most essential point in the performance of nephrostomy is that the tube should run a straight course through the parietes to the interior of the kidney The way to ensure this is, after the catheter has been inserted into the kidney and anchored to its capsule to return the kidney to its bed and to lower the bridge of the operating table Only then is it possible to ascertain where the exit for the tube should lie Often it is best to provide a special stab incision to accommodate the tube

Before making the stab Lane s tissue forceps are placed on the skin and muscles of the appropriate side of the incision, so that the abdominal wall can be held taut while the stab (it should be half as large again as the diameter of the catheter) is being made. In this way a perfectly straight exit for the catheter can be provided. The tube is drawn through the stab wound with a hæmostat. The lumbar incision is closed the perirenal space being drained by corrugated rubber brought out at the inferior end of the incision The catheter should be anchored to the skin not with a stitch but in the manner shown in Fig 937 p. 715 There are two advantages in employing this expedient (1) Infection of the stab wound is rendered improbable and (2) as there is no stitch to remove, the catheter can remain undisturbed until the time comes to change or remove it. This should be a minimum of fourteen days.

As soon as the patient has been returned to bed the catheter is connected to a collecting bottle. At all times precautions must be taken that the extra-corporeal portion of the catheter does not become kinked. It is important to keep the tube clear of blood-clot, especially during the first twelve hours after the operation, and this is done by injecting a measured quantity of saline solution down the tube at regular intervals.

Method 1 is indicated particularly when the kidney is obviously distended with urine or pus, and even if it were possible it is undesirable to deliver the kidney sufficiently for the renal pelvis to be exposed fully

In the convex border of the kidney towards its lower pole the point of the diatherm knife with the current switched off is plunged through the parenchyma toward the pelvis

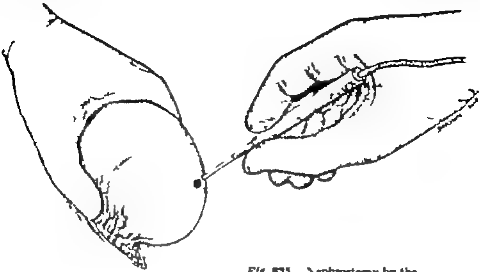

Fig 835.—Nephrostomy by the diathermy knife

The current, turned to "coagulating" as opposed to "cutting" is switched on and the knif is withdrawn slowly with a rotary movement (*Fig* 835). This burns a hole cleanly throug

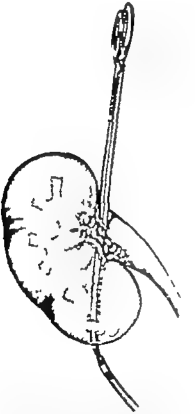

Fig 836.—Method of performing nephrostomy with the aid of a long hæmostat (*After J T Priestley*)

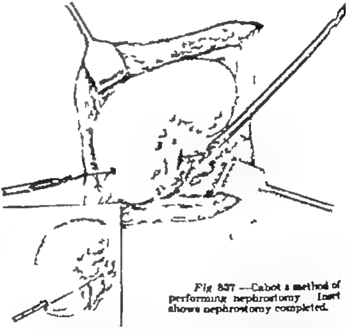

Fig 837.—Cabot's method of performing nephrostomy Inset shows nephrostomy completed.

the renal tissue When it is considered that the tunnel is adequate a Watson-Cheyne dissector is passed down it, and the probe-ended point will be felt between the finger and thumb from outside the renal pelvis. In many emergency conditions the last step is unnecessary for once the kidney substance has been penetrated as far as the interior of a calix, there will be a gush of pent-up pus or urine. Bleeding is somewhat free but not nearly as copious as when the kidney is incised with a scalpel After an adequate tunnel has been cut from the surface to the calyceal system a whistle tipped catheter or a rubber tube of suitable size with lateral eyes is passed into the opening until its tip can be felt

to lie in the pelvis of the kidney; it is then withdrawn sufficiently to ensure that the eyes of the tube are within or near the lowermost calix The catheter is then anchored to the kidney with a stitch (see p. 619). To make quite certain that the passage is unobstructed and the tube is lying correctly a syringe full of saline solution is connected with the tube and as the contents of the syringe are emptied the renal pelvis will be felt to balloon out. The tube is anchored to the capsule with a stitch.

In very urgent cases it is not always necessary to deliver the kidney So long as the fingers and thumb can be made to encircle the pedicle the operation of nephrostomy by the diathermy knife can be conducted quite well within the wound. This saves time and diminishes shock.

Method 2 is usually reserved for those cases in which the kidney can be delivered easily the renal pelvis displayed clearly and there is no contra indication to a somewhat more prolonged operation. On the other hand when a diathermy machine is not available the choice is narrowed to either methods 2 or 3

As is shown in *Fig* 836, a small incision is made into the upper part of the renal pelvis. A long hæmostat is passed into the lowermost calix its beak is driven through the renal parenchyma and capsule of the lower pole. The jaws of the hæmostat are opened just wide enough to grasp the tip of the catheter which is drawn into the renal pelvis. The hæmostat is then disengaged and withdrawn and the catheter is pulled gently so that its eyes come to lie within the lowest calix. The size of the catheter should be such that bleeding from the renal parenchyma is controlled by pressure of the catheter If oozing occurs it can be controlled by digital compression of the renal cortex around the catheter for several minutes. The incision in the renal pelvis is closed with a few interrupted sutures.

Method 3 is valuable when the kidney and its renal pelvis cannot be delivered sufficiently to perform method 2 with ease It is also the method to choose when the renal pelvis is mainly intra renal (*see Fig* 839). The eyed end of a malleable probe is passed through the convex border of the kidney near the lower pole, and it enters the caliceal system The probe is then withdrawn slightly and the main part of the shaft is bent so that when the probe is advanced its eye will enter the renal pelvis, where it will be felt if not seen. A small incision is made in the renal pelvis and the eyed end of the probe is made to protrude The remaining steps of the operation are made clear by a reference to *Fig* 837 The distal end of the catheter is cut obliquely and the now pointed end of the catheter is transfixed with a suture, which is tied. The other end of the suture is tied after passing it through the eye of the probe. A steady pull is made on the shaft of the probe and as the silk emerges, on the silk, and the catheter is drawn into the caliceal system and then through the renal parenchyma. A tiny incision through the capsule will aid the easy passage of the catheter Once the butt end of the catheter has been drawn through the lower pole, the remaining steps of the operation do not differ from those of method 2

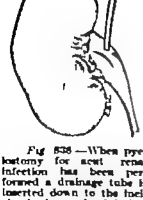

Fig 838 —When pyelostomy for acute renal infection has been performed a drainage tube is inserted down to the incision in the renal pelvis, but not into it. Free drainage of the perinephric tissues is also provided.

PYELOSTOMY (INSTEAD OF NEPHROSTOMY) IN SEVERE RENAL INFECTIONS

Mainly under local anæsthesia but supplemented by gas and oxygen and a relaxant, the kidney is exposed. The pelvis of the kidney is cleared of fat and is opened. Nephrostomy is not a satisfactory operation when performed upon a kidney with a thick, congested cortex. In such cases a liberal incision in the long axis of the renal pelvis is recommended as a substitute A drainage tube is not inserted into the pelvis, but free drainage is provided to the pelvis (*Fig* 838). Only when the cortex has been attenuated by dilatation of the calices (i.e., some degree of hydronephrosis is present before the infection occurs) or when the pelvis is mainly intrarenal (*Fig* 839), is nephrostomy indicated. In cases where pyelostomy has been selected, it can

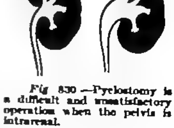

Fig 839 —Pyelostomy is a difficult and unsatisfactory operation when the pelvis is intrarenal.

with advantage be combined with decapsulation. Incidentally decapsulation will enable the parenchyma to be inspected for cortical abscesses. When the kidney is riddled with cortical abscesses and the functional integrity of the contralateral kidney has been proved nephrectomy is often a wise procedure

RENAL DECAPSULATION

The only indication for renal decapsulation is as an adjuvant to pyelostomy in cases of very severe pyelonephritis. The capsule is incised along the whole of the convex border

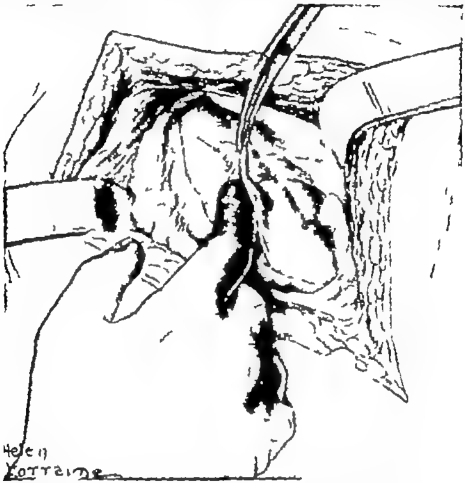

Fig 840 —Renal decapsulation. The capsule is stripped by the finger In urgent cases it is not necessary to deliver the kidney

The cut edges are picked up and the capsule peeled on each side towards the hilum (Fig 840).

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CHAPTER LI

THE BLADDER

TRAUMATIC RUPTURE OF THE BLADDER

With the increasing number of road accidents, cases of fractured pelvis complicated by rupture of the bladder have become more common. Of 1708 cases of fractured pelvis, 10 per cent had an associated rupture of the bladder. Of these, the rupture was extraperitoneal in 82 per cent and intraperitoneal in 18 per cent (Prather and Kaiser). On the other hand, owing to increased national sobriety, cases of intraperitoneal rupture of the bladder due to a blow upon the abdomen have become less frequent. This type of accident is more likely to occur in an inebriated person for two reasons: (1) The victim is off his guard, and consequently the abdominal musculature is not braced to receive the blow. (2) The bladder is likely to be full.

Partly on account of the more commodious pelvis, rupture of the bladder is decidedly less common in females than in males. In L. M. Bogart's series of 238 cases of rupture of the bladder, only 3 cases occurred in females.

The bladder of an infant and a child is mainly an abdominal organ. It does not attain its full pelvic position until the twentieth year. Therefore the chances of a rupture of the bladder being intraperitoneal are greater in a child than in an adult.

Extraperitoneal Rupture of the bladder is usually a complication of severe disruption of the pelvic architecture. Especially important are lateral crushing injuries producing separation of the symphysis pubis, fractures of the pubic rami and/or complete fracture-dislocation of the pelvic girdle. Such injuries are liable to result in tearing of the bladder by stress upon its moorings, or exceptionally by perforation by a spicule of bone. Although a distended bladder is much more vulnerable than an empty one, a bladder containing even a little urine is not immune to extraperitoneal rupture.

Extraperitoneal rupture usually occurs on the anterolateral wall of the bladder close to the bladder neck, thus allowing urine to extravasate into the prevesical space (cave of Retzius). The extravasated urine, admixed with blood, fills the space and infiltrates upwards to the umbilicus and laterally as far as the anterior superior iliac spines, and inferiorly to the apex of the prostate. Confined at first between the peritoneum on the one hand and the fascia transversalis on the other, the extravasated urine causes early necrosis of the intervening connective tissue; infection soon follows. Untreated, the extravasated urine can pass through the sacrosciatic notches to the buttocks, through the obturator foramina to the thighs, and via the inguinal canals to the scrotum or labiæ.

Intraperitoneal Rupture occurs through the dome or posterior surface of the bladder. The tear is usually vertical, owing to the arrangement of the muscle bundles.

DIAGNOSIS

The symptoms of ruptured bladder are not infrequently masked by multiple injuries, shock, or inebriation. All patients with a fracture of the pelvis should be suspected of having an injury of the lower urinary tract until proved otherwise. "Has the patient passed urine since the accident?" is a question that must be asked in every relevant case. In only 13 per cent of cases does a patient with a ruptured bladder pass urine, and when he does so almost invariably the urine is blood-stained (Gilbert and Dodson). On the other hand, case histories reveal that 37 per cent of patients with a fractured pelvis but *without* demonstrable injury to the urinary tract suffer from retention of urine, and 6 per cent with dysuria (Meredith Campbell). Furthermore, 30 per cent of such patients pass urine containing gross or microscopical quantities of blood derived presumably from bruised or torn vesical mucous membrane.

Extraperitoneal Rupture.—After the initial shock has passed off, one of the first symptoms is an intense desire to micturate, but either no urine is passed or only a few

drops of blood-stained urine with great effort. The spasms recur at intervals. Extravasation occurs into the prevesical space causing a tender swelling above the pubes (*Fig* 841). Patients with a fractured pelvis will complain of pain when compression or distraction is applied to the iliac crests pressure over the pubic rami is often painful In the male

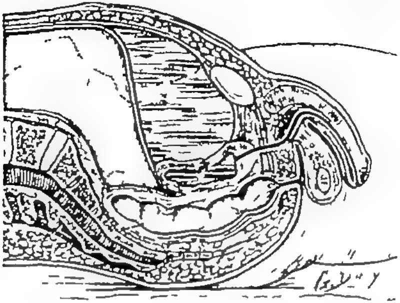

Fig. 841 —Extraperitoneal rupture of the bladder The bladder is empty or practically so. (Cf. *Fig.* 842.)

extraperitoneal rupture of the bladder can be readily distinguished from intrapelvic rupture of the urethra by a rectal examination, for in the latter the prostate is impalpable (*see Fig* 806 p. 580). If a patient with extravasation of urine is not seen until 24 hours after the accident, almost certainly pyrexia and toxicity will be in evidence

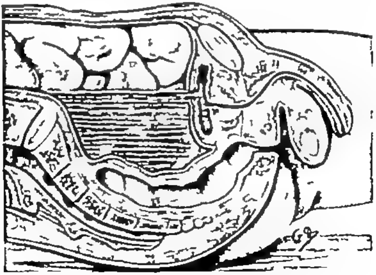

Fig 842 —Intraperitoneal rupture of the bladder

Intraperitoneal Rupture.—There is sudden agonizing pain in the hypogastrium often accompanied by severe shock and perhaps syncope. However in a few minutes the shock passes off and the pain lessens—so much so that sometimes the patient resumes his occupation—but the abdomen soon commences to distend because of paresis of intestinal coils bathed in urine (*Fig* 842) Although there are exceptions, following the accident the patient has no desire to micturate On examination a varying degree of abdominal

distension is present. In spite of the fact that the patient has not passed urine since the accident, there is no dullness above the pubes corresponding to a distended bladder. Usually there is tenderness in the hypogastrium. Abdominal auscultation discloses an absence of or greatly decreased intestinal sounds. If the amount of urine in the peritoneal cavity is considerable, shifting dullness can be elicited. Rectal examination often reveals a tender bulging in the rectovesical pouch. When the urine is sterile symptoms and signs of peritonitis are delayed for several hours.

When a patient with intraperitoneal rupture of the bladder is not seen until 24 hours or more after the accident, signs of obvious peritonitis make the differential diagnosis from rupture of some other viscus impossible unless, of course, the patient has passed little or no urine since the accident.

Methods of confirming the Diagnosis.—

1. *Mensuration.*—The passage of a urethral catheter, noting the amount and character of the urine that is evacuated, the introduction of 4 oz. (125 ml.) of sterile saline solution, and the attempt to recover it, has proved inconclusive so often that it should not be employed. Fallacies can arise: (a) From the tip of the catheter entering the peritoneal cavity through the rent, when it is possible for the same amount of fluid to be recovered as was injected. (b) Similar misleading information can accrue from an intraperitoneal rupture becoming sealed temporarily by a coil of small intestine, or by blood-clot; (c) Recovery of less fluid than was instilled can result from the eye of the catheter becoming blocked by blood-clot.

2. *Cystoscopy* is another method not to employ, for, contrary to what might be thought, even in the hands of an expert the information gained is often unreliable. When the tear is a comparatively large one the bladder cannot be distended. When the puncture is small, and blood-clot does not obscure the perforation, whether or not the tear extends through all coats of the bladder is doubtful. An absolute contra-indication to cystoscopy is when the patient has a fractured pelvis. Placing the patient in the lithotomy position is not only painful, but it is likely to increase displacement of the fracture.

3. *Retrograde Cystography* is the only reliable method of proving the integrity or otherwise of the bladder. The method should not be attempted until the patient has been treated for shock, if such is present. It is carried out at the same time that radiographs of the bony pelvis are taken. Combining excretory pyelography with retrograde cystography yields valuable additional information concerning the upper urinary tract.

Excretory urography, so valuable for visualizing the kidneys, is untrustworthy as a means of diagnosing a ruptured bladder. After the 60-min. films of the kidney have been exposed, retrograde cystography is commenced, but should the blood-pressure be too low for prompt urinary excretion, i.e., below 90 mm. Hg, the excretory urography part of the examination is omitted. The opaque medium for retrograde cystography should neither be iodized oil (danger of oil embolism) nor a solution of sodium iodide (irritating and painful), but a 10 per cent solution of iodoxyl, of which there are several proprietary preparations, such as pyelosil.[1] These solutions are aseptic, non-irritating, and, if absorbed, non-toxic. The quantity needed for this examination is 150–200 ml. Strict precautions that the injection is carried out aseptically are fundamental. The penis or the vulva is cleansed thoroughly, the area draped with sterile towels, and the anterior urethra irrigated before a catheter is passed. The opaque fluid is injected slowly through the catheter into the bladder by means of a bladder syringe.

An anteroposterior view of the bladder is usually sufficient for the diagnosis of rupture, although an oblique view can be made in addition if thought desirable. In intraperitoneal rupture the appearance of the cystogram is often characterized by coils of gas-filled small intestine occupying the basin of the pelvis delineated by the contrast medium which has escaped through the rent into the peritoneal cavity. A small extraperitoneal extravasation is sometimes obscured by the shadow of a full bladder. It is therefore advisable to empty the bladder via the catheter and then to expose a final film.

Performed in this way, retrograde cystography leaves no doubt as to the integrity or otherwise of the bladder. By this means only can an intraperitoneal (*Fig.* 843) or extraperitoneal (*Fig.* 844) rupture of the bladder be diagnosed with irrefutable precision, and early enough to enable the operation to be undertaken with a very good prospect of success.

The question arises where this examination should be carried out. In most cases, if a portable X-ray apparatus is available, the best place to carry out the examination is in the operating theatre where asepsis can be assured. On the other hand, at the Boston

[1] Glaxo Laboratories Ltd., Greenford, Middlesex.

City Hospital the patient is placed on a Bradford's[1] frame and conveyed thus to and from the X-ray department (G. C. Prather).

When facilities for radiography are lacking one must rely on physical signs, and if there are reasons to suspect a rupture of the bladder one should operate. To wait until the diagnosis is certain is often fatal. When the poor condition of the patient and uncertainty of diagnosis make some form of confirmatory test impelling the following is of service: a catheter is passed after a small bowl of water has been placed between the patient's

Fig. 843.—Retrograde cystogram showing a small intraperitoneal rupture of the bladder (G. C. Prather). (*By courtesy of the Journal of the American Medical Association.*)

Fig. 844.—Extraperitoneal rupture of the bladder demonstrating the tear-drop shape of the bladder due to its elevation by extraperitoneal extravasation of blood and urine. (*J. E. Kickl ghter.*)

thighs. 30 ml. of air is injected into the bladder through the catheter with a syringe and the end of the catheter is immediately pinched tightly or clamped. The distal end of the catheter is then inserted beneath the water in the basin; the clamp is released. If a generous amount of air bubbles through the water it is presumptive, but not conclusive evidence that the bladder wall is intact. A possible danger of this method is air embolism.

OPERATION FOR RUPTURED BLADDER

In but few conditions is the call for operation more urgent. In cases complicated by a fractured pelvis, except for temporary immobilization, treatment of the fracture must remain in abeyance for at least four or five days after the operation. The patient must be transferred from his bed to the operating table as carefully as possible in order not to increase shock or further displace broken bones. If a Robert Jones abduction frame or a Bradford's frame of such a size as to fit the patient can be found, this is the best means of immobilizing the patient in his transit to the operating table, and for some hours after his recovery from the anæsthetic. If no frame is obtainable, recourse must be made to a towel across the pelvis held in place by sandbags.

Blood transfusion or infusion of a blood substitute should continue throughout the operation.

Having placed the patient, with due care on the operating table, the area should be draped so as to give access to the whole abdomen and the towels so arranged that, if required, a catheter can be introduced into the bladder from the external urinary meatus, which is cleansed with that possible objective in view.

The incision is made in the middle line from just beneath the umbilicus to a finger's breadth above the symphysis pubis. It is carried through the aponeurosis, following which the recti abdominis muscles are retracted. If there is an extraperitoneal rupture urine and blood will well up from the prevesical space. Usually suction and mopping will clear the field temporarily. If hemorrhage is excessive gauze packing should be inserted.

[1] Bradford's frame is a rectangular splint made from gas-piping with a canvas mattress stretched between the sides. There is a division in the canvas for nursing purposes.

The anterosuperior aspect of the bladder with its peritoneal reflection is identified and displaced upwards by gauze dissection. At this point the peritoneal cavity should be inspected to rule out the possibility of an associated intraperitoneal injury. This is best accomplished by incising the peritoneum just above its attachment to the bladder. The opening need not be large. Rapid inspection will determine if there is free blood or urine in the peritoneal cavity. If none is found, the opening in the peritoneum is closed promptly. On the other hand if free fluid is found the opening in the peritoneum is enlarged by continuing the incision upwards. Should there be an intraperitoneal lesion of a viscus other than the bladder attention is directed first to appropriate measures to remedy this lesion.

Intraperitoneal Rupture of the Bladder

Having opened the peritoneum, aspirate or mop up the urine. Have the table tilted slightly downward by the head, and pack off the intestines so as to leave the pelvis clear.

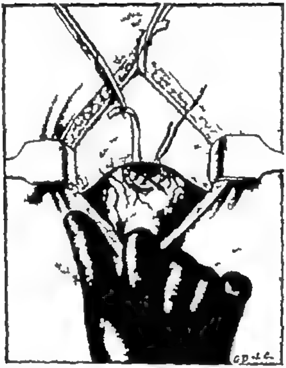

Fig. 843 — Suturing an intraperitoneal rupture of the bladder. Note the finger in the suprapubic bladder incision raising the empty bladder from the depths of the pelvis, and the abdominal pack in position.

Remember to count the packs and have their number recorded. Attention is then directed to the extraperitoneal prevesical area.

By gauze dissection strip the prevesical pad of fat (which covers the peritoneal reflection) upwards, thus opening freely the prevesical space. When the bladder is empty it is often difficult to identify. It can be recognized by the muscle-bundles in its walls and prominent veins on its surface. Should identification still prove difficult, a gum-elastic catheter passed from the external urinary meatus will simplify identification. Make an incision into the bladder as for suprapubic cystostomy (see *Fig.* 849, p. 632). Having ligated any bleeding points in the bladder wall introduce a finger into the bladder. With the left index finger in the bladder the interior can be explored thoroughly and the rupture or ruptures usually will be found. If the rupture is on the posterior wall or in any part of the dome with the finger in the bladder as a retractor this portion can be brought into view. It will now be found convenient to change from the right side of the patient to the left, the better to stitch the bladder. As speedily as possible the rent should be closed with interrupted sutures of No. 1 chromic catgut penetrating deeply the bladder musculature (*Fig.* 843). It is unnecessary and a waste of time to attempt to close the rent layer by layer or to employ any form of fancy suturing. *Of the greatest importance*

in the entire surgical procedure is the establishment of liberal suprapubic bladder drainage. Once the rent has been closed, a Marion's tube or a ⅜-in. (1·0-cm.) drainage tube[1] is passed into the suprapubic bladder incision and the bladder closed snugly around it. With such free drainage bleeding and extravasation cease and small unsutured bladder wounds will heal. The packs are now removed from the peritoneal cavity and the table is levelled.

Unless there is frank peritonitis, after again mopping up any fluid which may be present the peritoneal cavity can be closed completely; otherwise a suprapubic peritoneal drain is left in position. It is essential to insert a generous strip of corrugated rubber to drain the prevesical space.

The abdominal wall is closed in layers. The suprapubic drainage tube and the corrugated rubber are each anchored to the skin with a stitch.

Extraperitoneal Rupture of the Bladder

The difficulties of distinguishing between an extraperitoneal rupture of the bladder and an intrapelvic rupture of the urethra are referred to on p. 668. If the rupture is entirely extraperitoneal, it is necessary only to perform suprapubic cystostomy as described for intraperitoneal rupture of the bladder and to drain the prevesical space freely, preferably with a Penrose drain. If the rupture happens to be on the anterior wall, the drainage tube can be inserted through the rent and the bladder closed around the tube. If it is not so conveniently placed, and by the exploring finger in the bladder the rent is found to be a large one, it may be closed by interrupted sutures applied by the transvesical method. But this is not necessary; indeed, it is to be disparaged, for with dual drainage of the bladder and the prevesical space the rent will heal, whereas if sutures are introduced, unless care is taken, it is possible to include a ureter in a stitch.

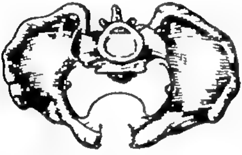

Fig. 846.—A tear of the bladder may be held apart by separation of the pubic bones. (*After Sir Reginald Watson-Jones.*)

Before completing an operation for extraperitoneal rupture an assistant should pass a catheter from the external meatus; by seeing and palpating the beak of the catheter within the bladder we are assured that the urethra is intact.

It is possible for a tear in the bladder near the vesical outlet to be held apart by separation of the pubic bones (*Fig.* 846). In such cases the bladder should be dissected free from the pubic bone and the rent closed about a Marion's tube, which should emerge from the bladder as high as possible.

Combined Intra- and Extraperitoneal Rupture of the Bladder

Although not infrequent in war wounds of the bladder, combined intra- and extraperitoneal rupture of the bladder is encountered comparatively rarely in civil practice. In these cases the operative procedure is exactly the same as for an entirely intraperitoneal lesion, except that drainage of the prevesical space is more liberal.

AFTER-TREATMENT OF RUPTURED BLADDER (ALL CASES)

Blood and parenteral fluid are administered as necessary. In cases of intraperitoneal rupture, as soon as the patient has recovered from shock he should be propped up gradually into the sitting position. Unless there are reasons to substitute another antibiotic penicillin therapy is commenced as soon as possible, and continued for at least a week. When the patient is permitted to take fluids by mouth, a soluble sulphonamide such as sulphatriad can be given in addition.

The method *par excellence* of keeping the bladder empty, and thus ensuring that further extravasation of urine is impossible, is to employ suction (*see* Stedman's Tube, p. 633, or Cleland's Sump Drainage, p. 189). When the case is complicated by a fractured pelvis the treatment of the fracture is sometimes a problem. Immobilization by sandbags

[1] If no suction apparatus is available in the ward, the largest size de Pezzer type of catheter should be substituted. Whatever suprapubic tube is employed, it should be a large one.

is the simplest expedient, and in cases with but little displacement such immobilization is adequate until union occurs (6–8 weeks), although the application of a plaster cast (*see* p 678) after a sufficient time has elapsed for the patient to recover from the operation (5–6 days) is preferable. In cases with wide separation of the pubic bones a pelvic sling that can be made with stout canvas and suspended by balanced weights from an overhead beam is the most effective method of maintaining apposition of the fragments. With the fracture treated in this manner up to a week can intervene before reducing the fracture and applying a plaster cast.

When a cast is applied a large window must be cut to permit the necessary exposure of the suprapubic wound.

Prognosis.—Statistics show that when operation is performed within twelve hours the mortality is 11 per cent when operation is delayed twenty four hours it is 53 per cent. Without operation, as in the days of ancient Greece it is 100 per cent.

CONTUSION OF THE BLADDER (INCOMPLETE RUPTURE)

Seven of 11 patients with contusion of the bladder reported by F R. DeLuca et al. on admission were suffering from shock, but each of these 7 patients had either a fractured pelvis, a head injury or a fractured extremity to account for the shock. All 11 patients passed varying amounts of blood in the urine, and all not in coma or profound shock reported pain and tenderness in the hypogastrium. However there was no evidence of abdominal rigidity which is usual when extravasation into the peritoneum or prevesical space has occurred. The most difficult aspect of diagnosis in these cases is to differentiate between contusions and lacerations without perforation, and ruptured bladder or intra pelvic rupture of the urethra. In cases of rupture of the bladder and intrapelvic rupture of the urethra urgent operation is imperative, while in lacerations of the bladder without perforation the treatment is strictly conservative.

Cysto-urethrography as soon as the patient has recovered sufficiently from shock is invaluable in determining or eliminating the presence of a ruptured bladder or intrapelvic rupture of the urethra.

The treatment of contusion or laceration of the mucosa of the bladder consists in strict bed rest, a high fluid intake, antibiotic therapy and sedation. In the rare event of profuse hæmaturia an indwelling urethral catheter should be inserted for irrigation, to aid in the evacuation and prevention of clots in the bladder When clots are troublesome these authors have found instillations of streptokinase and streptodornase (*see* p. 140) extremely valuable.

EXTRAPERITONEAL HÆMORRHAGE IN FRACTURED PELVIS

Extraperitoneal hæmorrhage always occurs when the pelvis is fractured, and may or may not be associated with extraperitoneal rupture of the bladder or intrapelvic rupture of the urethra. The prevesical tissues contain many arteries and veins of not inconsiderable size, and when the pelvis is fractured several of these are likely to be torn. The hæmorrhage is often copious, and occasionally is severe enough to prove fatal. In a number of instances this extravasation of blood so compresses the bladder that on cystography its rounded shape is altered to that of a pear-shaped organ, well named by Prather and Kaiser the tear-drop bladder (*see Fig* 844 p 626). When, in the course of an operation for extraperitoneal rupture of the bladder or intrapelvic rupture of the urethra, the prevesical space has been opened and blood pours out, it is seldom possible to locate the source of the hæmorrhage. Once the blood has been evacuated, usually most of the bleeding ceases, particularly after temporary packing has been inserted. From time to time hæmorrhage is brisk enough to warrant repacking the prevesical space and its lateral recesses, and retaining the packing for 48 hours.

INJURY TO THE BLADDER DURING OPERATION

This error is easily committed when performing *suprapubic drainage of the peritoneal cavity* It is of course almost impossible if, as is usually the case, the left hand can be introduced through a laparotomy incision to act as a guide But if suprapubic peritoneal drainage is being performed *per primum*, as would be the case in a collection of pus occurring some days after the appendix has been removed, the danger is a very real one. To have

the patient catheterized before he comes to the theatre is insufficient—I know this to my sorrow. The bladder must be emptied *after the patient has been anæsthetized.*

Femoral herniotomy, particularly when the low operation was in general use, proved to be a source of injury to the bladder. Before operating upon a femoral hernia, strangulated or otherwise, the bladder should be emptied by passing a catheter after the patient has been anæsthetized. This is the only way of being absolutely certain that the organ is empty.

During hysterectomy (particularly panhysterectomy), both abdominal and vaginal, and also during excision of the rectum, the same precautions must be taken to ensure that the bladder is empty, for this accident is liable to occur in any of these operations.

Remedying the Accident.—Wounding of the bladder during a surgical operation, recognized at the time, can be treated most successfully by closure of the bladder in two layers, and drainage of the bladder by a large urethral catheter for seven days. Penicillin and a sulphonamide should be administered for at least a week. If this accident is not recognized at the time, suprapubic cystostomy must be carried out as soon as possible after the diagnosis has been made. In necessary cases the peritoneal cavity should be drained. In order that the suprapubic drainage tube and the peritoneal drainage tube should not be in juxtaposition, it is best to bring the latter out through a stab incision centred over the middle of one or other rectus abdominis.

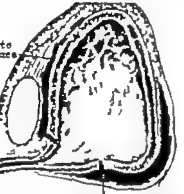

Fig. 847.—Extravasation of urine following perforation of the prostatic capsule during transurethral prostatectomy. (*After Kenneth Walker.*)

Accidental Perforation of the Prostatic Cavity or the Bladder Neck during Transurethral Prostatectomy.—Produces sudden severe pain in the epigastrium or lower part of the thorax. The pain sometimes radiates to the shoulder joint, usually to the left. These symptoms, of course, are only manifest if the patient is under spinal anæsthesia. If the accident is recognized immediately it can be treated by drainage of the bladder by a large urethral catheter and the administration of antibiotics (H. F. Kenyon). Should an interval of hours or longer elapse before this complication (*Fig.* 847) is recognized, suprapubic drainage of the bladder and drainage of the prevesical space is essential. When sogginess can be felt per rectum, or there are other reasons to believe that the perforation is posterior, drainage of the pararectal tissues via the perineum (*see* p. 840) is imperative.

Perforation of the bladder can also occur as the result of destruction by cystodiathermy of a neoplasm of the bladder. It is more likely to happen as the result of the use of a cutting loop (resectoscope) than a plain electrode.

Other Causes of Rupture of the Bladder.—(1) After forcible irrigation or catheterization of a pathological bladder. (2) During litholapaxy. (3) As a complication of difficult labour—spontaneous rupture of the bladder during the puerperium has been reported after normal delivery and from perforation of an infected diverticulum of the bladder. (4) Extravasation of urine through the intact bladder wall has occurred following irrigation of the bladder with a solution of hyaluronidase with a view to removing phosphatic encrustations. Finally the female bladder has been ruptured from the patient falling in a squatting position on to a projecting object. The rupture occurred through the anterior vaginal wall (A. H. C. Walker).

ACUTE CYSTITIS

Theoretically it might reasonably be assumed that to drain an acutely inflamed bladder would give it rest and relieve the patient of the agonies of strangury. *Cystostomy in acute cystitis is absolutely contra-indicated.* Its dangers are manifold. They include a spread of the infection, e.g., ascending pyelonephritis, virulent cellulitis commencing in the prevesical space, and anuria. It is wise to refrain from even passing a catheter during the early stages of acute cystitis and to rely entirely upon conservative treatment. A mid-stream specimen of urine is secured to determine the sensitivity of the infecting organism or organisms to antibiotics and sulphonamides. In the meantime the best practice is: (*a*) To place the patient on a high fluid intake; (*b*) Order a fluid

intake and output chart; (c) Render the urine alkaline by suitable doses of sodium citrate (see p. 575). Minims 30 (2 ml.) of tinct. hyoscyami every three hours helps to relieve pain; (d) Pending the bacteriological report, administer a broad-spectrum antibiotic.

After the ultra-acute stage is passed i.e. in a matter of thirty-six hours, it is permissible to pass a catheter This serves as an opportunity:—

1 To obtain a specimen of bladder urine for further bacteriological examination.

2. To ascertain if there is any residual urine (in acute cystitis the bladder is usually tonically contracted, hence the futility of suprapubic cystostomy).

3. To irrigate the bladder very gently with warm saline solution under low pressure.

4. To leave in the bladder 4 oz. (123 ml.) of sterile liquid paraffin, for its soothing effect.

The last measure is particularly valuable some of the paraffin is retained in the bladder for upwards of three days and there is no contra-indication to further instillations.

When the acute symptoms have abated and the urinary output is adequate excretory urography may help to elucidate the cause of the cystitis.

SUPRAPUBIC CYSTOSTOMY

Catastrophic catheterization predisposes to shock and anuria The danger of emptying suddenly a full bladder was known to our forefathers. The unavoidable abruptness with which the bladder is emptied by the operation of ordinary suprapubic cystostomy puts catastrophic catheterization into the shade No doubt exists in my mind that to open the bladder suddenly is extremely dangerous.

On Christmas Eve, 1921 I was asked to perform suprapubic cystostomy upon a man who had been admitted the previous night with acute retention. His retention, due to an enlarged prostate had been relieved soon after admission by the passage of a bi-coudé catheter It was also pointed out that the morrow was Christmas Day with its arduous calls upon resident staff. Suprapubic cystostomy was duly performed, the bladder being considerably distended at the time, and the urine gushed forth. This was the last urine that the man passed. For four days he had complete anuria which failed to respond to the remedies then in vogue. He died in coma on the fifth day At the necropsy a benign enlargement of the prostate was found, but the kidneys showed no gross abnormality

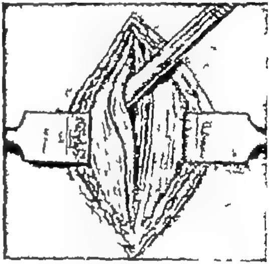

Fig 848.—Suprapubic cystostomy The fibres of the rectus are separated with the handle of the scalpel.

It is improbable that this disaster would have occurred had suprapubic catheterization (see p. 642) been substituted for ordinary suprapubic cystostomy for with the former the outflow of urine can be controlled. *Open suprapubic cystostomy is therefore contra indicated in acute retention of urine and especially in acute retention with overflow* The only exception to this rule is in cases of acute retention due to an enlarged prostate when the blood urea estimation proves to be within normal limits and the operator is prepared to undertake immediate prostatectomy

Indications.—The indications for open suprapubic cystostomy as an emergency should be limited to the following —

1 As a means of treating extraperitoneal rupture of the bladder

2. As an integral part of the treatment of intraperitoneal rupture of the bladder

3. As the preliminary step in the treatment of complete rupture of the urethra.

4 For the evacuation of blood-clot. This should be reserved for those cases where diligent washing through a catheter has failed to evacuate all the blood-clot.

5 For the removal of foreign bodies that cannot be extracted by an operating cystoscope

The Operation.—A catheter is passed and the bladder is distended with an antiseptic solution such as acriflavine 1–10 000

The incision, about 2–2½ in. (5·0–6·3 cm.) in length, is made in the middle line immediately above the pubis. The rectus sheath is opened near the middle line and the fibres of the rectus muscle are split and separated with the handle of the scalpel (*Fig* 848). Retractors are inserted, and the index finger of the left hand dives deeply into the

prevesical space (cave of Retzius), behind the symphysis pubis. The fat pad and cellular tissues are hooked upwards. A little dissection with the handle of the scalpel renders this upward reflection possible. This step is the most important in the operation. Using this technique the peritoneum is never seen, and is protected until the bladder is opened. The bladder can be recognized by its muscle-fibres and the veins coursing over its surface. Still keeping the forefinger hooked in the upper angle of the wound, the bladder is caught in a pair of Lane's tissue forceps a fairly substantial bite is necessary in order to prevent tearing out. A second tissue forceps is applied a little to the left of the first and is given to the assistant to hold tension is applied, and a scalpel, with its cutting edge towards the symphysis, is plunged into the bladder between these forceps (*Fig* 849) On removing the scalpel the finger is inserted into the bladder and the organ explored. If a mechanical sucker is available the escaping lotion can be aspirated as it gushes forth. A Thomson-Walker tray is a good alternative method of collecting the escaping fluid.

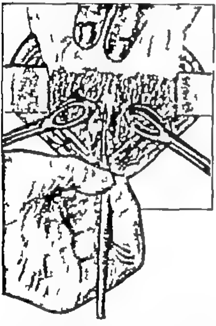

Fig. 849 —Suprapubic cystostomy The bladder is picked up at two points by Lane's tissue forceps. Between these a scalpel is passed into the bladder The blade of the knife is directed towards the pubes and the opening into the bladder enlarged in a downward direction only; alternatively transverse incision can be employed. Note the gauze swab protecting the peritoneum.

The edges of the bladder are then secured with a hæmostat on each side and the Lane's forceps are removed. When the bladder has been emptied a mushroom headed catheter (*Fig* 850) is introduced, stretched on a long hæmostat (*Fig* 851). The bladder is now closed about the tube, so as to make a water tight junction. The ends of the

Fig 850.—A, De Pezzer catheter B, Malecot catheter

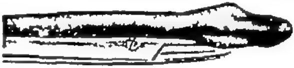

Fig 851 —Method of stretching de Pezzer catheter with a hæmostat.

uppermost suture are left long and brought through the rectus sheath on each side to be tied later this is the means of preventing the collapsed bladder sinking into the depths of the wound. The shaft of the catheter is brought out of the extreme upper end of the wound, to avoid adherence of the bladder to the symphysis pubis. The rectus sheath is approximated with interrupted sutures except at the extreme lower end, where a corrugated rubber drain is placed always drain the prevesical space. The operation is afterwards brought to a completion by closing the skin and anchoring the tubes with suitable skin stitches.

A stitch should always anchor the catheter to the skin. This little precaution will prevent the annoying complication of the semiconscious patient pulling out his catheter

After treatment.—*If a mushroom-headed catheter has been employed* it must be connected to a closed-system drainage bottle (see p. 641). If bladder irrigations are considered necessary a solution of 1 2000 bradosol is advised, but if the infection appears to be responding to antibiotic therapy it is better to omit the irrigations which, of necessity break the closed system of drainage temporarily Should drainage be required for a lengthy period it will be unnecessary to change the catheter at

least for several weeks. The old catheter is removed by a sudden sharp pull and the new one, stretched on its special introducer (*Fig* 852) is insinuated down the track, which by this time is well lined with granulation tissue

Fig 852.—De Pezzer catheter stretched on its special introducer ready for inserting into the bladder

SUPRAPUBIC CYSTOSTOMY WITH SUCTION DRAINAGE

Another method of maintaining drainage of a suprapubic cystostomy wound is by suction. This is a splendid principle; urine is aspirated as soon as it enters the bladder—the antithesis of suprapubic boxes, where there must always be a stagnant pool which

Fig 853.—Stedman's tube. The Stedman fitting enables a rubber catheter to be retained within Marion's tube.

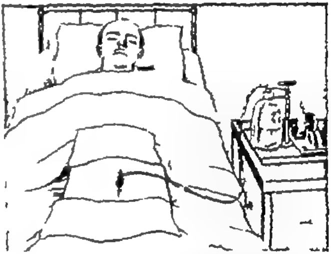

Fig 854.—Suction drainage using a Stedman's tube. Note the division in the bedclothes, which are protected by sterile towels. The area is covered with a towel supported by a bed-cage.

invites infection. Stedman's tube consists of a Marion's tube with an ingenious fitting to hold a rubber catheter within it (*Fig* 853) The catheter is connected to a suction apparatus. Alternatively Cleland's sump drain (*see Fig* 242, p. 180) can be employed A most important nursing detail is that the wound is left completely uncovered by making a division in the bedclothes. A sterile towel above and below protect the hypogastrium from the bedclothes. Every detail of this simple and efficient method is shown in *Fig* 854 and unless the wound is cared for in this way the method will *not* give satisfaction. If a bed-cage is placed across the patient's lower abdomen the exposed area can be covered with a towel.

BLADDER WASHES

There are a number of bladder washes available Bradosol 1–2000 is a good routine solution to employ the most usual alternative being 1–10 000 silver nitrate. An exception is made in cases of persistent alkaline cystitis when a 1 per cent solution of phosphoric acid is used on alternate days.

FOREIGN BODIES IN THE BLADDER

The removal of foreign bodies from the bladder by cystoscopic manœuvres is beyond the scope of this work. Usually the object has been in the bladder for weeks or longer

Fig. 833.—A hair fastener in the bladder

(*Fig.* 833) before giving rise to symptoms, and the accompanying cystitis makes suprapubic cystostomy the only method which should be employed. After removing the foreign body the bladder is drained with a Malecot catheter

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CHAPTER LVI

RETENTION OF URINE

The relief of acute retention of urine by catheterization is too often looked upon as a trivial matter, insufficient attention being directed to asepsis and technique. Actually it is a matter of the highest importance and can be made an interesting study not beneath the dignity of the most fastidious.

In undertaking the treatment of acute retention the three fundamental objectives are (1) To prevent infection (2) To avoid laceration of the urethra (3) To obviate the necessity for repeated catheterization.

If repeated catheterization could be carried out with care and due observance of asepsis it would do little harm. It is because sooner or later a time arrives when the patient becomes distended at an inconvenient moment that an element of risk creeps in.

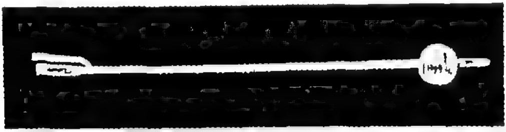

Fig 856.—Foley's catheter (C. R. Bard, Inc., New Jersey)

Fig. 857 —Tiemann's catheter

Fig 858.—A coudé catheter

Fig 859 —A bicoudé catheter

Fig 860.—An olivary tipped gum-elastic catheter

Catheters.—If it can be passed, the ideal catheter with which to relieve retention of urine in either sex is a Foley's (*Fig* 856), which can be retained so easily to permit the bladder to be emptied slowly and for as long after that has been achieved as is deemed necessary. Often it is impossible to pass a balloon-ended catheter in cases of organic obstruction, and for that reason, in a male Tiemann's catheter (*Fig* 857) offers many advantages. It is made of firm rubber withstands repeated boiling, and, being angulated, it is suitable for prostatic obstruction. Its olivary end also enables a urethral stricture of moderate calibre to be negotiated frequently. A coudé (*Fig* 858) or bicoudé (*Fig* 859) catheter can sometimes be passed in cases of prostatic obstruction when a Tiemann's fails. If in an emergency a suitable gum-elastic instrument cannot be obtained and a rubber catheter will not pass the obstruction a large silver catheter can be tried. Olivary tipped gum-elastic catheters (*Fig* 860) are especially valuable in cases of urethral stricture.

Methods of negotiating a fine stricture of the urethra are described on p. 673.

Choosing a Catheter of Suitable Size.—The narrowest part of the urethra is the external urinary meatus ; therefore, unless there is good reason to suspect that the urethra is strictured it is usual to choose a catheter with a diameter a little less than that of the meatus. In this connexion the scale of calibration of catheters (*Fig* 861) will prove most useful. The French scale[1] is used widely

ENGLISH	FRENCH	ENGLISH	FRENCH	ENGLISH	FRENCH
3	8	7	14	11	20
4	9, 10	8	15, 16	12	21, 22
5	11	9	17	13	23
6	12, 13	10	18, 19	14	24, 25

Fig 861.—A guide to the calibration of catheters.

Sterilization.—All modern catheters can be sterilised by boiling It should be appreciated that gum-elastic catheters are boilable, and with due care they can withstand repeated boiling The catheter should be plunged for two minutes into water already boiling ; it must be removed carefully by its wide end, and dropped into sterile cold water or cold weak antiseptic lotion before use. Elastic and nylon catheters withstand boiling without special precautions, but they are inferior to gum-elastic, for gum-elastic is never too soft or too rigid. If, however the catheter is to be retained, a plastic catheter is said to be less irritating to the urethral mucous membrane than gum-elastic, and this is definitely so in the case of low-grade red rubber

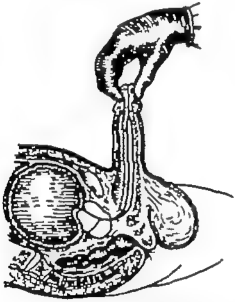

Fig 863.—Anterior urethra distended with local anæsthetic solution, which is then massaged and milked posteriorly

Fig 862.—A urethral syringe.

Fig 864.—A penile clamp.

Aseptic Catheterization.—By taking a little trouble, catheterization can be performed aseptically and painlessly Each of the selected catheters is inserted into a half length of Penrose tubing (Paul's small rubber tubing will do). The catheters thus ensheathed are placed in a dish of water and so manipulated that there is no air inside the catheters or between each catheter and its Penrose overcoat (G C. Tresidder). The contents of the dish are tipped into a sterilizer and boiled for five minutes. During this time the operator scrubs his hands.

The penis is grasped with a swab moist with boric lotion or weak flavine solution. The prepuce is retracted and the glans cleansed thoroughly with another moist swab. A sterile towel is placed over the thighs and beneath the penis. The anterior urethra should be irrigated in every case This can be performed readily with a syringe filled with the same weak antiseptic used for cleansing the glans. A urethral syringe (*Fig* 862), an inexpensive

[1] The French scale is commonly known as Charrière's scale, so called after Joseph Charrière (1803–1876), a Paris surgical instrument maker

item, should be looked upon as a necessary part of the equipment. In its absence a Record syringe will suffice

Anæsthetizing the Urethra.—There are a number of suitable and safe solutions for this purpose. Amongst the best are 4 per cent procaine, 1–1500 percaine and 2 per cent decicain. Admittedly in the case of acute retention the anæsthesia will only extend to the seat of the obstruction, but even this is a distinct asset. One-eighth or one-quarter ounce (4–8 ml.) of the solution should remain in the urethra for five minutes (*Fig* 863). A penile clamp (*Fig* 864), another useful piece of equipment, obviates the necessity for holding the lips of the meatus together during this period.

Introduction of the Catheter.—Aseptic lubricating jelly is squeezed into the urethra from a tube. The penis is kept stretched vertically and the catheter within the Penrose tube is passed into the meatus. The Penrose tubing is thin enough to feel the catheter. Still keeping the penis stretched vertically the catheter is passed onwards, observing the watchword for all urethral instrumentation—*non vis sed arte*. At no time during its passage is the catheter uncovered.

In the female catheterization is performed usually by a nurse. The vulva must be cleansed with pieces of cotton-wool wrung out in an antiseptic being wiped in an upward direction. It is most desirable that the urethra be washed out, and above all the use of a sterile lubricant should be insisted upon. Frequently these precautions are omitted.

Antibiotic and Chemotherapy.—Whenever catheterization is undertaken a urinary antiseptic should be given. In the case of a single catheterization, sulphatriad is usually sufficient, but in a susceptible bad risk case the surgeon will probably think it wise to give an antibiotic of his choice as well. These precautionary measures reach their zenith of importance when the catheter is left in situ, and a good combination in this instance is sulphatriad and achromycin. For dosages see pp 573, 570.

THE INDWELLING CATHETER

The Prevention of Urethritis.—In cases where an indwelling catheter is to be employed, the prevention of urethritis is to a great extent a matter of thoughtful care. Naturally such infection is more likely to supervene in the male with 10 in. (25 cm.) of urethra than in the female, with a urethra one tenth as long. In nearly all cases infection commences in the anterior urethra, and it is with the object of washing out any organisms that have invaded the urethra, through which no urine has passed for hours, that the anterior urethra

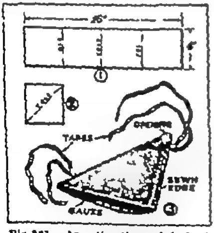

Fig 865.—An antiseptic penile jacket is made easily from gauze and tape

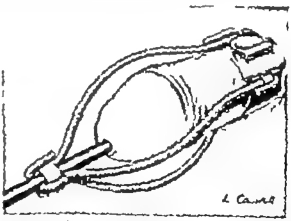
Fig 866.—A method of tying in a urethral catheter using pipe-cleaners. The penile jacket is not shown.

is irrigated with a mild antiseptic solution before catheterization is attempted. Next one must consider the means of retaining the catheter. Any method that compresses the distal end of the penis on to the catheter should be condemned utterly for this prevents urethral secretions from escaping through the meatus alongside the catheter. The ideal method in this respect is drainage by means of a Foley's catheter, for if it is no larger than 20 French and the patient is an adult, urethral secretions can escape unhindered.

An Antiseptic Penile Jacket can be made quite easily with gauze and tape (*Fig* 865). It is boiled before use and wrung out in flavine solution. It is applied in all cases in which

a catheter is to be retained. By this means infection alongside the catheter—a potent source of urethritis—is prevented.

There are a large number of methods by which a non balloon ended catheter can be retained in the urethra. One of those which can be applied over the penile jacket should be chosen.

The Pipe-cleaner Method (*Fig* 866).—After the catheter has been passed, four pipe-cleaners are fastened around the base of the penis with 1 in (2 5 cm.) flexible adhesive strapping The four ends are then brought to the catheter and fixed there with a narrow strip of adhesive plaster in such a way that each pipe-cleaner has a definite bow and stands well away from the glans penis. The ends at the base of the penis are then bent back or cut off. It is important to apply the band of strapping loosely around the penis to avoid constriction and œdema.

Fig 867 —Hamilton Bailey's lead strap.

Instead of employing flexible adhesive plaster at the base of the penis, a lead strap (*Fig* 867), which holds three pipe-cleaners, will be found most practical and comfortable for the patient

DECOMPRESSING THE OVERDISTENDED BLADDER

Once a catheter has been introduced into an overdistended bladder it is advisable to allow the urine to escape slowly and the more distended the bladder the slower should be the rate of emptying Such is the view of the majority of surgeons who have interested themselves in this important subject.

A minority believe that slow decompression is unnecessary They attribute the suppression of urine that sometimes follows sudden emptying of the bladder not to reflex anuria following catastrophic catheterization, but to infection: the rapidity with which anuria sometimes follows sudden emptying of the bladder (see p 631) would seem to put this explanation out of court. C. Wells states that slow decompression is an ideal rather than an accomplishment. This certainly is untrue if the technique about to be described is followed. Indeed, no good reason has been put forward why this additional safeguard should not be practised.

Fig. 868.—This pattern of intravenous drip chamber gives very accurate control of the outflow of urine.

Fig 869 —An ordinary glass nozzle can be used to connect the catheter with the rubber tubing.

Fig 870.—Silver connecting link for use between catheter and tubing[1] prevents kinking and ensures a water tight junction.

Decompression of the bladder by means of an intravenous drip chamber (*Fig* 868) is the method of choice. Its simple principles can be employed even in remote districts, asepsis is assured, and the rate of emptying the bladder is controlled with mathematical precision.

Into the mouth of the catheter is inserted a nozzle (*Fig* 869). An ordinary glass nozzle serves the purpose but the silver right-angled connexion (*Fig* 870) has many advantages. In order to support the penis connected to the apparatus, a piece of broad adhesive plaster is applied to the thighs so as to form a sling between them. Upon this rests the penis. The free end of the nozzle is then connected to the tubing of the intravenous saline dripper

[1] Made by Kipling, 8 Gloucester Way London, E.C.1

The screw clamp of the dripper is set to allow forty to sixty drops per minute to escape (*Fig* 871). If the retention is of long standing the rate of emptying is somewhat slower

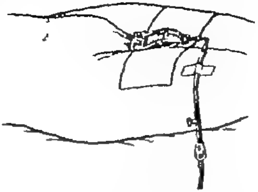

Fig 871.—Decompression of the bladder using the dripper of an intravenous saline apparatus.

Recompression.—If by some mischance the bladder has been decompressed too rapidly it is logical to refill the bladder partially with normal saline solution, and to start decompression anew

POST-OPERATIVE RETENTION OF URINE

The reason why a patient having undergone an operation is unable to pass urine is sometimes apparent at others it is indeterminable. Naturally when the patient is an elderly male, prostatic obstruction, hitherto latent, is suspected, but there is no means of confirming the suspicion unless a soft rubber catheter is arrested in the prostatic urethra.

Some patients have a bashful bladder this type of individual hesitates to ask for a urinal, and is unable to micturate in the presence of another person. Many cannot urinate while lying or sitting in bed. Another common cause of post-operative retention of urine and one that is not often thought of, is sedation. When a patient is given sufficient morphine or other drug to relieve post-operative pain frequently the desire to micturate is suppressed until the bladder is overdistended. Should the patient be spare a swelling in the hypogastrium can be seen, felt, and percussed. On the other hand, if the patient is obese or the abdomen is bandaged especially with flexible adhesive plaster not infrequently post-operative retention of urine is overlooked for the following reason the bladder being very full, the patient passes small quantities of urine frequently just sufficient to prevent dribbling overflow It is in such cases that if these small amounts have been charted it will be apparent that the urinary output is much lower than it should be, and even if the patient is obese, careful percussion of the hypogastrium will reveal an overfull bladder

Pain on attempting to micturate is yet another frequent cause of retention of urine after lower laparotomy herniorrhaphy and anal operations. Retention of urine following an operation for prolapsed intervertebral disk, or particularly after laminectomy can be ascribed to trauma of the spinal cord. After operation upon the pelvic viscera, particularly excision of the rectum and total hysterectomy retention of urine is so common that it is usual to forestall it by inserting a self retaining catheter at the conclusion of the operation In a quarter of cases of excision of the rectum the retention lasts more than two weeks (P C. Watson).

While outstanding examples have been given, the list is by no means exhausted Indeed, retention of urine can be encountered after an operation on any part of the body for instance it is quite common after an operation for cataract.

Treatment.—It can be stated categorically that parasympathetic stimulating drugs should be avoided.[1] Too often they are valueless but their particular danger is that of

[1] Provided the patient has not undergone an abdominal operation, carbachol (Moryl), ½–1 ml., is permissible but in view of the dangers of its promiscuous use by house surgeons, it is safest to forbid parasympathetic stimulants in cases of post-operative retention of urine altogether

necessity they stimulate the intestinal musculature, and on that account by their action on the unaffected upper reaches of the intestine as opposed to that affected by paresis below are liable to precipitate paralytic ileus.

Methods of relieving post-operative retention of urine vary with the probable cause, whether or not overdistension has been allowed to occur and whether or not infection of the urine is present or has supervened. The measures recommended are set out in the form of a surgical crescendo —

1 *Simple Expedients are tried.*—

a. The male patient is given a warmed bed bottle the female patient is sat upon a bed pan. The bed should be screened and the patient left undisturbed for at least ten minutes.

b In cases of lower laparotomy or herniorrhaphy a firm binder against which the patient can push is well worth trying

c. If there is no contra-indication, let a male patient dangle his legs over the side of the bed while he attempts to empty the bladder

d With the surgeon or his deputy's signed permission only (the case history sheet should be marked up P R.N) a male patient is allowed to stand supported, and a female patient is permitted to sit on a commode.

2. *Catheterization is undertaken* with a catheter no larger than 15 French, and preferably one of the Foley type. In order to minimize the risk of infection, besides the precautions set out already it is a good practice to instil 1 oz. (30 ml.) of a 1 per cent solution of mercurochrome or a 1–500 solution of silver nitrate into the emptied bladder If less than 15 oz. (450 ml.) of urine are withdrawn, it is probable that catheterization will not be required again, so the catheter is removed.

3. *Indications for an Indwelling Catheter* —Post-operative, like all other varieties of retention of urine, if not diagnosed and relieved early allows the bladder to become overdistended and paresis of its musculature ensues. Consequently if the catheter is removed after the bladder has been emptied one must be cognizant of the fact that further attacks of overdistension will occur more easily and with less pain. Therefore when the bladder contains more than 15 oz. so probable is it that recatheterization will be required, that it is advisable to retain the catheter The end of the catheter is clamped (a screw clamp is better than a spigot) and wrapped in sterile dry gauze. Every two hours the clamp is loosened, and the urine evacuated is collected. The end of the catheter is wiped with alcohol, reclamped, and rewrapped in gauze. The amount of urine retrieved is measured and charted. Sometimes, especially if the patient is receiving intravenous fluid therapy he will ask for the catheter to be unclamped more frequently If such requests are repeated, and the quantity recovered is 11 oz. or less, it can be assumed with some degree of confidence that spontaneous micturition will be re-established if the catheter is withdrawn.

Although some trouble from the nursing standpoint, this method of managing post operative retention pays handsome dividends uninfected urine remains uninfected, and the catheter is not retained one day longer than is necessary When the method is not employed, and the catheter is connected to a collecting bottle, adjudicating when the catheter shall be removed is guess-work. The alternative is to connect the catheter with the apparatus about to be described.

CLOSED SYSTEM OF CATHETER DRAINAGE

Regardless of whether urine issuing from a catheter is draining the bladder via the male or the female urethra, or through a suprapubic or perineal system or through a ureterostomy pyelostomy or nephrostomy it should never be allowed to drain into an open mouthed receptacle The incidence of ascending infection is nearly halved (W Goldie) by connecting the catheter to sterile tubing conducted to a sterile collecting bottle and employing irrigations only if clot retention demands them. Changing a full receptacle for an empty one then becomes the principal cause of failure of the system, which is minimized by bringing a sterilized empty receptacle and placing it in close proximity to the full one thereby effecting the change-over expeditiously If infection occurs in spite of these precautions, *Esch. coli* is the commonest infecting organism, and a high proportion of strains are streptomycin resistant.

Ogier Ward's collecting bottle can be improvised easily. As seen in *Fig* 872 air entering the bottle through the inlet passes through gauze containing lightly packed *formalin* tablets. The litre flask contains 4 oz. (115 ml.) of 10 per cent formalin solution.

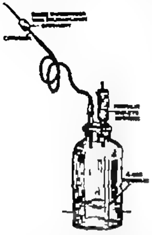

Fig 872.—Method of managing an indwelling catheter in the female. The antiseptic drainage bottle is suitable for suprapubic and urethral drainage in either sex. (*After Ogier Ward*.)

The K.C.H.[1] *drainage apparatus* which was designed for use after prostatectomy provides a closed antiseptic system of bladder drainage from the time of operation onwards, that gives warning if the catheter becomes blocked. The apparatus (*Fig* 873) consists of a large jar (A) with a small one (B) fixed within its metal lid. The lid is provided with a rubber washer and makes an air tight fit on the large jar. In the base of the small jar is a hole ½ in. (1.3 cm.) in diameter which is closed by a rubber washer on the end of a spring loaded plunger (C). After connecting the autoclaved apparatus to the catheter with sterile tubing, urine (admixed with blood) drips into the small jar the contents of which is released at intervals of half an hour by the nurse pressing the plunger. Should the catheter become blocked pressing the plunger will yield no result and the nurse reports the matter forthwith. If, on the other hand the small jar becomes filled to capacity before the plunger is pressed, urine in excess of its capacity will overflow through a hole in its side into the larger jar. Thus, once it is assumed that the urine is no longer heavily blood stained, and the catheter is draining satisfactorily the plunger need not be operated.

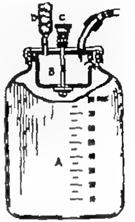

Fig 873.—King's College Hospital closed system urine collecting apparatus.

The air vent (D) is filled loosely with formaldehyde tablets. 4 oz. (115 ml.) of 10 per cent formaldehyde solution is placed in the large jar prior to use. The capacity of this large jar is 80 oz. (2.27 l.), consequently, changing the full jar for a fresh one (a spare jar is provided) is a relatively infrequent procedure. The jars are marked in ounces, which permits the nurse to record the urinary output accurately with a minimum of trouble. After emptying, the jar not in use is cleansed thoroughly and filled with a 1–2000 solution of hibitane[2] to sterilize it.

CATHETER URETHRITIS, PROBABLE OR ESTABLISHED

When a urethral catheter has to remain in situ for five days or more even if special precautions to prevent it have been taken, some degree of urethritis is likely to supervene. Consequently should the catheter become blocked or should the catheter come out, or should a purulent urethral discharge be observed, and it is considered improbable that the patient will pass urine naturally it is most unwise to attempt to re-drain the bladder by a urethral catheter.

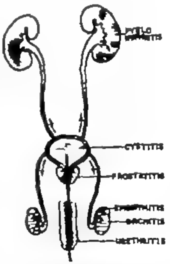

Fig 874.—Complications are especially liable to follow changing a urethral catheter in the presence of urethritis. (*After C. G. Scorer*.)

To change a catheter in the presence of urethritis entails a grave risk of carrying the infection from the anterior urethra to the deep urethra and to the bladder and from thence to other parts of the urogenital system (*Fig* 874). Consequently rather than replace a catheter through an infected urethra it is wiser to perform suprapubic catheterization of the bladder (see p. 642) or alternatively if this is undesirable because of an operation wound in the lower abdomen, perineal urethrostomy (see p. 647) should be substituted.

[1] King's College Hospital. The apparatus is made by Charles F. Thackray Ltd., Leeds.
[2] Hibitane-(bis-p-chlorophenyldiguanido-hexane acetate). Imperial Chemical (Pharmaceuticals) Ltd., Wilmslow, Manchester.

RETENTION OF URINE DUE TO ORGANIC OBSTRUCTION

Prostatic obstruction is by far the most frequent cause of retention of urine In r
per cent of cases such obstruction is due to adenomatous enlargement of the gland;
10 per cent of cases it is the result of prostatic carcinoma, while in about 3 per cent t
cause is fibrous contracture of the prostate

When the retention arises in hospital, where the patient is undergoing treatment f
another condition, probably catheterization is the best course In endeavouring to pas
catheter when the obstruction is due to enlargement of the prostate, the difficult poi
to pass is where the middle lobe commences, i.e about half way along the prostatic ureth
The double bend of a bicoudé catheter helps to surmount this obstacle At times the l
index finger inserted into the rectum may help to lever the tip of the catheter into t
bladder It should be noted that the pressure must be exerted not on the lateral lob
but over the apex of the prostate (*Fig* 873)

In the common event of the patient being admitted because of retention of urine d
to an enlarged prostate, provided the general condition is satisfactory the time-honour
½ gr (0 016 G) of morphine and a hot bath can be tried In a small proportion of ca
the retention is relie
naturally in the bath.

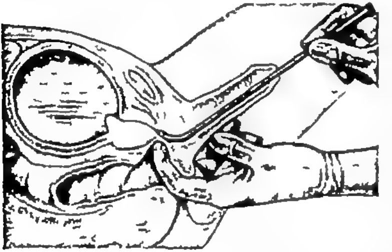

Fig 873.—A finger in the rectum aiding the passage of the catheter in a difficult case of prostatic obstruction.

Immediate Prostat
tomy.—Some urologists c
sider that the corr
treatment of acute
acute-on-chronic retent
of urine due to prosta
obstruction is immedi
prostatectomy This p
supposes that the surgeo
a practised prostatecton
and that he has availa
throughout the 24 ho
radiological services for
cretory pyelography
laboratory facilities to pr
that the patient's re
function is adequate T
majority of surgeons do
subscribe to this view because (*a*) a very high percentage of patients admitted w
acute retention of urine are clinically unfit for an immediate major operation; (*b*) t
course leaves no time to meditate as to which type of operation (retropubic suprapu
enucleation endoscopic resection) is best suited to the particular case and (*c*) it m
be remembered that in at least 10 per cent of cases of prostatic obstruction the lesio
not an adenomatous hypertrophy (*see above*)

Avoidance of Urethral Catheterization.—There is a growing body of the profession w
consider that it is wiser to avoid urethral catheterization in these cases because: (*a*
may be impossible to pass a urethral catheter (*b*) catheterization sometimes ca
considerable hæmorrhage from the engorged prostate (*c*) a tied-in urethral cathe
entails strict confinement to bed (*d*) above all, if the catheter must be retai
for more than a few days there is always the danger of infection, which so of
proves disastrous. The alternatives to urethral catheterization are suprapubic catheteri
tion which is very popular and perineal urethrostomy the advantages of which sho
be better known.

SUPRAPUBIC CATHETERIZATION

While the main indication for this procedure is prostatic obstruction, it can be emplo
in cases of overdistension of the bladder from other causes. The only contra-indicati
are when the patient has had recent hæmaturia (*see* CLOT RETENTION p. 640), when th
is a recent wound or a scar near the middle line of the lower abdomen, and when
abdominal wall is infected

Again it is emphasized that ordinary suprapubic cystotomy which allows the urine to gush forth, must be avoided rigorously

The aim is to introduce a mushroom-ended catheter into the bladder without spilling even a drachm of urine There are several ways of achieving this end.

Technique I.—The essential armamentarium is a No. 28 reinforced Malecot catheter The bladder perforator shown in *Fig* 878 is inexpensive, and a most useful instrument to possess. If the special perforator is not available, the Malecot catheter can be stretched over a narrow bladed scalpel (*Fig* 876) This is not so satisfactory and requires some deftness, but in cases of necessity it serves its purpose. When this makeshift is employed there is inevitable leakage about the catheter which is undesirable.

Fig. 876.—A narrow-bladed scalpel can be used as a bladder perforator in the absence of a special instrument.

One per cent procaine is injected into the skin in the middle line from the symphysis to 1 in. (2.5 cm.) below the umbilicus. A skin incision is made and towels are clipped to the wound edges. The rectus sheath on either side is infiltrated within the limits of the incision, great care being taken not to prick the underlying distended bladder The linea alba is then incised. The cellular tissue and fat in front of the distended bladder are hooked up with the fingers, and the bladder wall with tortuous veins coursing over it, is seen clearly (*Fig* 877). All is in readiness for the introduction of the catheter The bladder perforator is armed with a No. 28 reinforced Malecot catheter which is stretched on the perforator as shown in *Fig* 878 (*inset*) The actual introduction is performed in the twinkling of an eye, with a short, sharp stab (*Fig* 878) The introducer is disengaged while the end of the catheter is pinched, prior to clipping

Fig 877.—Suprapubic cystotomy The suprapubic fat pad is reflected upwards by gauze dissection. The peritoneum is thus protected; in most cases it is not even seen. Note the vessels coursing over the bladder musculature a spectacle that enables the operator to recognize the bladder immediately and permits him to avoid these vessels when the bladder is punctured.

it with a hæmostat. A few drops only of urine escape around the puncture It is essential to push the mushroom head of the catheter well into the bladder otherwise it is liable to be extruded when the distended bladder contracts (*Fig* 879). The catheter is brought out through the abdominal incision as high up as is practicable. This little precaution will aid considerably when the time comes for the ... either retropubically or suprapubically

Drainage of the prevesical space is provided using a strip of corrugated rubber. The abdominal wall is approximated and the skin is closed with silkworm-gut sutures, not

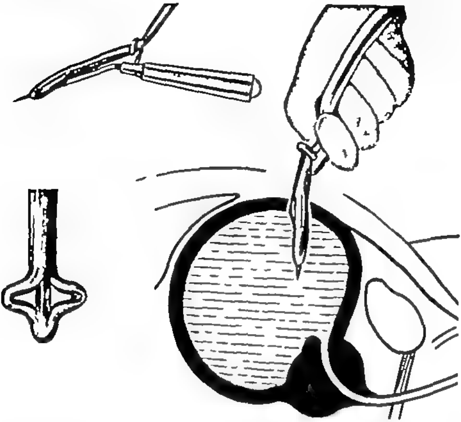

Fig 878.—Introducing a suprapubic catheter into the exposed over full bladder by means of the bladder perforator

forgetting to anchor the catheter with one of these. In order to minimize displacement the anchoring of the catheter to the skin is reinforced by a narrow strip of adhesive plaster

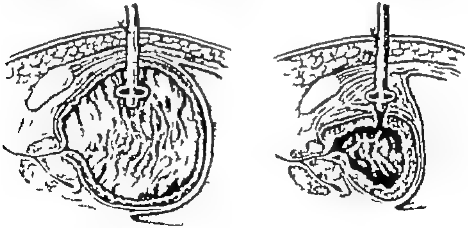

Fig 879.—Unless the expanded end of the catheter is pushed well into the bladder it will be dragged out as the bladder contracts, for the catheter is fixed to the skin by a stitch.

entwined around the catheter and fixed firmly to the skin. Alternatively a St. Peter Hospital suprapubic catheter shield (*see Fig* 882 p 643) can be employed to retain the catheter. The suprapubic catheter is then connected to the intravenous dripper by glass connexion (*Fig* 880)

Technique 2.—The suprapubic catheter is inserted into the bladder through a small incision made 1 in. (2.5 cm.) below the level at which the anterior surface of the bladder curves upwards and backwards to form the dome. This site is ascertained by careful palpation after muscular relaxation has been enhanced by the administration of a suitable dose of morphine. The incision is between ½ and ¾ in. in length, and the strong fibres of

Fig. 880.—Decompression of the bladder after the insertion of a suprapubic catheter.

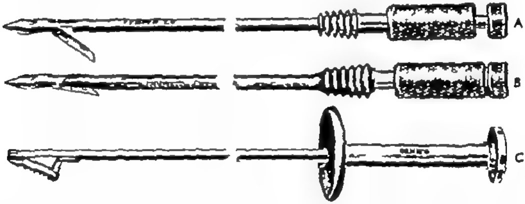

Fig. 881.—A, The suprapubic catheter introducer. B, The catheter stretched on the introducer. C, The advancer. (E. W. Riches.)

the linea alba are severed in the length of the incision. The puncture of the bladder can be made with a trocar and cannula of suitable dimensions to accommodate a stretched Malecot catheter. With a trocar and cannula a good deal of spill while introducing the catheter is inevitable, and the operation can be performed better and more expeditiously with a special instrument designed for the purpose, such as that of Riches, Lane or Anscombe. Riches's instrument is the best known and the least complicated of these; it will therefore be described. After the special catheter has been mounted on the introducer (*Fig.* 881 A, B), it is passed through the incision in the linea alba until its sharp point touches the surface of the bladder. The patient is warned that he will experience momentary pain, and the instrument is passed into the bladder with a short, sharp thrust. The introducer is removed and the advancer (*Fig.* 881 C) is passed down the lumen of the catheter and its expanding end is opened. By its agency the catheter is carried into the depths of the bladder so that the tip lies near the trigone. This important step being accomplished, the advancer is removed. A stitch is used to secure the catheter to the skin, and the anchorage is reinforced with a strip of adhesive plaster. Alternatively a St. Peter's Hospital suprapubic catheter shield (*Fig.* 882) can be

Fig. 882.—St. Peter's Hospital pattern suprapubic catheter shield.

employed. This obviates the necessity for placing a skin stitch through the catheter. The shield is drawn down the lubricated catheter in the same way as a cuff for a jejunostomy catheter (*see* p. 525) full precautions being taken not to pull the catheter out of the bladder during the manipulation. The shield is kept in place by strips of adhesive plaster.

Dangers.—While eminently satisfactory in most cases, a possible danger of the method is wounding the peritoneum. In a careful study of a large series of cases, Scorer has been able to demonstrate that in a small percentage of cases the catheter track passes through the opposed layers of the lowest fold of the peritoneum without harm However, if the junction is not watertight it is possible for peritonitis to develop from this undesirable happening Hemorrhage is another possible danger one cannot choose an avascular portion of the bladder through which to introduce the catheter as is possible in Technique 1

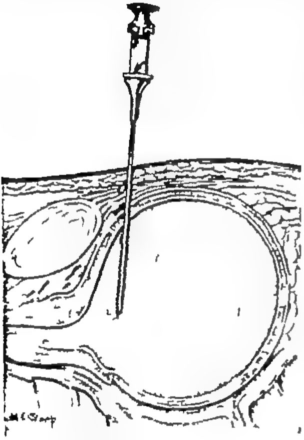

Fig 883.—Suprapubic puncture with a lumbar puncture needle The needle is inserted very near the top of the symphysis pubis.

Suprapubic Puncture with a Hollow Needle.—Suprapubic puncture (*Fig.* 883) is a useful method of relieving acute retention when catheterization has failed and the circumstances are extenuating If the circumstances remain extenuating, and a catheter still cannot be passed, as in the case cited below the puncture may be repeated. Repeated

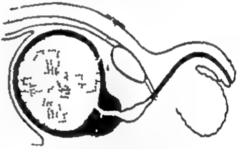

Fig 884.—Suprapubic puncture has been performed and the bladder has been allowed to refill to the point of tension. Leakage is taking place through the cal puncture into the cave of Retzius.

puncture is only permissible in exceptional circumstances, for it is dangerous to allow the bladder to refill after it has been punctured leakage is liable to occur into the cave of Retzius (*Fig* 884). By one of those curious coincidences which pursue surgical practice, I operated during the same night upon two cases of extravasation of urine with spreading cellulitis of the abdominal wall due to this cause. One case occurred within the hospital, whilst the other was admitted from an outlying country district. It is obvious that the smaller the puncture hole the less likely is this leakage to occur therefore the finest lumbar puncture needle obtainable is recommended for the operation.

The following experience shows the inestimable value of suprapubic puncture :—

Whilst employed as surgeon on a small gun-boat during the first world war I was summoned in the middle of the night to an officer s cabin. The case was one of acute retention from stricture and the bladder extended half way to the umbilicus. Morphine, gr ¼ (0 016 G), and hot flannels to the hypogastrium produced no relief. There was a very small selection of instruments aboard, and none could be made to pass the stricture The pubes were therefore shaved and suprapubic puncture performed with a lumbar puncture needle. The next morning catheterization was again attempted, but the stricture was impassable. The retention was relieved three times by suprapubic puncture before the patient could be got ashore to hospital. No extravasation took place. The patient recovered after internal urethrotomy

PERINEAL URETHROSTOMY

Perineal urethrostomy is an alternative to suprapubic catheterization and is particularly valuable in young males and debilitated old men. This operation opens the urethra where the lumen is widest, and consequently a comparatively large catheter can be introduced with room to spare: the free drainage alongside the catheter explains the low incidence of epididymo-orchitis that accompanies the operation when compared with that of an indwelling catheter lying along the whole length of the urethra.

The catheter emerges at a site not readily accessible to the prowling hand of a difficult patient. Should this small wound become infected, the drainage is so excellent that complications are negligible. Leakage alongside the catheter is most uncommon. Whether the patient is ambulant or bed-ridden, drainage is downwards from the lowest point of the bladder. Changing the catheter can be carried out without the slightest difficulty. Transurethral resection of the prostate can be performed via the urethrostomy opening, which allows the use of a larger resectoscope than would be admitted by the anterior urethra. The development of a fistula or a stricture at the site of the urethrostomy is unusual, but if the catheter has to be retained for many weeks a fistula does result because of epithelialization of the walls of the opening. In the few cases where operative closure of the urethrostomy is necessary it is easier to perform than closure of a suprapubic fistula.

Technique.—Perineal urethrostomy is performed easily under caudal anæsthesia. The patient should be placed in a rather exaggerated lithotomy position, with the thighs well flexed at the hip-joints. After cleansing the external genitalia and the perineum, the area is draped in the usual way. A metal sound of medium size is passed into the urethra so that its tip enters the posterior urethra and the curve presents in the perineum. The scrotum is held out of the way in the manner described on p. 670. The assistant maintains the sound in this position, and the surgeon grasps the curve of the instrument firmly between the forefinger and the thumb of the left hand, about midway between the base of the scrotum and the anus. An incision 1 in. (2.5 cm.) long is made directly on to the sound so as to expose the metal clearly. If grasping pressure on the sound is maintained, bleeding is minimized. The edges of the urethra are caught in tissue forceps, the sound is withdrawn, and a suitable catheter is introduced between the tissue forceps and passed into the bladder. If a Foley's catheter is chosen, the bag is distended with water by the assistant, while hæmorrhage is arrested. Bleeding, which is profuse because the incision traverses the cavernous tissue surrounding the urethra, is effectively and rapidly controlled by the insertion of a continuous suture of No. 1 plain catgut. This suture is so passed as to approximate the cut edges of the bulbo-spongiosus muscle to those of the urethral mucous membrane, traversing such corpus spongiosum that lies between them. The catheter should emerge from the urethra at the anal end of the wound. The skin and fat are approximated loosely by a single stitch: it is well to leave the wound partially open for free drainage. It is always advisable to secure the catheter to the skin with a suitable stitch, even when a Foley's catheter is employed, for the bag may break within the first few days. After four days a track is formed, and the reinsertion of a catheter presents no difficulty. A dry dressing is applied to the perineum.

If considered advisable, bilateral ligation of the vasa can be carried out.

Wounds in the perineum are notorious for becoming moist and odorous, but nevertheless are famous for freedom from toxic reaction and eventual good healing. In the unusual event of the wound becoming unduly purulent, Sitz baths are recommended if the patient is sufficiently ambulant. If not, then hot fomentations are applied. Bladder wash-outs are ordered only if the urine is infected. The catheter should be changed at intervals from two to four weeks, depending upon the amount of urinary salt deposited within its lumen. Encrustation is detected easily by rolling the catheter between the finger and thumb. Encrustation occurs particularly when the urine is alkaline and can be counteracted by acidifying the urine or by giving the patient acid bladder washes.

RETENTION WITH OVERFLOW

The necessity for controlled decompression of the bladder reaches its zenith in cases of retention with overflow. The organ has been distended for weeks or months, and to empty it suddenly contravenes general principles and common sense. It is remarkable how these patients, with their bladders distended above the umbilicus and with a blood urea

of perhaps 230 mg per cent often walk about with comparative unconcern, and it is difficult to convince the patient and his friends of the seriousness of the condition. To have had more than twenty five consecutive cases of retention with overflow recover (several of them of the type depicted in *Fig* 885) indicates something more than a coincidence because before adopting the method about to be described the mortality was very high. In this condition there is no need for undue haste in commencing decompression of the over-distended bladder

Fig 885 —One of the cases of retention with overflow referred to in the text just prior to the insertion of suprapubic catheter

Treatment.—The bladder is decompressed very slowly by means of a saline dripper To this end the upper limit of the bladder is marked upon the abdominal wall, and the aim is to lower the dome of the bladder not more than 2 in (5 cm) per day What is probably an important consideration is that each patient is catheterized (either per urethram or more usually suprapubically) in the operating theatre where asepsis can be assured. In cases where a urethral catheter has been employed, the penile jacket undoubtedly helps to prevent infection. Soon after decompression has started, the slow administration of continuous 5 per cent dextrose solution is commenced. The outflow of urine is set at say fifty drops the inflow of dextrose solution regulated to, say forty drops per minute It is, of course essential that the rules concerning the administration of all intravenous solutions are observed. An accurate balance-sheet of intake and output is of vital importance With this treatment it is astonishing to observe the blood-urea fall as much as 100 mg per cent in twenty four to thirty-six hours.

RETENTION DUE TO A URETHRAL STRICTURE

One of the results of the early and efficient treatment of gonorrhœa by antibiotic therapy is that retention of urine due to a urethral stricture is becoming much less frequent. When it is found that a Tiemann's catheter is arrested in the bulb of the urethra (the most frequent site of urethral stricture) or in the penile urethra, an olivary-ended catheter of suitable calibre as tested by trial, sometimes can be inserted. A Phillips catheter (*Fig* 886) is a very good instrument in cases

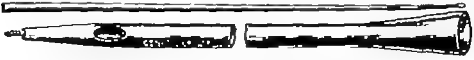

Fig 886 —Phillips catheter The guide is inserted through the stricture after which the catheter is screwed on to the guide

Fig 887 —The faggot method of passing bougies.

of stricture and one with which it is impossible to lacerate the urethra When such an instrument has not been at hand I have often used a fine gum-elastic bougie, passed, if necessary by the faggot method (*Fig* 887) This answers the purpose admirably for urine trickles slowly alongside the instrument and lo! our very objective namely slow decompression of the bladder—is accomplished

To retain the bougie in place a piece of cotton is tied tightly around it and the long end are bound to the penis by adhesive plaster

RETENTION DUE TO IMPACTED URETHRAL CALCULUS

Retention of urine due to this cause is uncommon. The retention may be partial or complete, but the pain accompanying the condition is intense. Palpation of the urethra usually reveals the site of the impaction, which is not infrequently behind a urethral stricture or narrow external urinary meatus.

The stone is impacted in the fossa navicularis.—The treatment is simple and precise. Perform meatotomy (*see* p. 681), and the stone will be passed when the patient micturates.

The stone is impacted in the penile urethra.—When the obstruction is partial, Bivona's device is occasionally effective. Local anæsthetic is injected and sufficient time is allowed for it to take effect. The patient passes urine and suddenly interrupts the stream by compressing the end of the penis. The urethra is thereby dilated and the stone may be swept onwards.

When this course is impracticable (a child) or is ineffective, so agonizing is the pain that the most practical method of procedure is first to administer a low spinal anæsthetic in the case of an adult or a general anæsthetic when the patient is a child. Possibly this in itself may be effective, and, as soon as anæsthesia has been produced, the stone may be extruded at the head of a jet of urine. Under anæsthesia there is no difficulty in making out the exact location of an impacted urethral stone by palpation. The important thing is to ascertain whether or no there is a urethral stricture. If the operator is skilled in its use, the urethroscope will decide this question. If there is the slightest doubt, it is safer to presume that a stricture is present, and to remove the stone through a longitudinal incision in the floor of the urethra.

The stone is impacted in the posterior urethra.—Again an anæsthetic should be given. An attempt is made to pass a catheter. Occasionally the stone can be pushed backwards into the bladder, whence it can be removed at the time or later by crushing or by performing suprapubic cystotomy. If, as is more usually the case, gentle catheterization fails to dislodge the stone, the best expedient is to relieve the retention by suprapubic catheterization and to extract the stone at a later date, as was done in the following case:—

Fig. 888.—Large stone impacted in the prostatic urethra.

G. H., aged 20, was admitted with acute retention. Catheterization had been attempted, and he was bleeding from the meatus. Per rectum a stony mass could be felt in the region of the prostate. The retention was relieved by decompressing the bladder with a catheter introduced suprapubically. Later a radiograph (*Fig.* 888) showed a large calculus in the prostatic urethra. Fourteen days later the stone was removed via the bladder after incising the internal urinary meatus. It was found that a No. 8 French bougie could be passed through a stricture of the bulbous urethra. The suprapubic wound healed, and the patient was advised to attend regularly for dilatation of the stricture.

CLOT RETENTION

Blood-clot in the bladder sometimes causes acute retention of urine. I have seen several cases follow nephrolithotomy, and have also encountered an unusual example in a middle-aged woman where, later on cystoscopy, the hæmorrhage was found to be coming from a Hunner's ulcer of the bladder. Curiously, although the hæmaturia is often severe, clot retention seldom occurs in connexion with papillomata and malignant growths of the urinary tract. The passage of a catheter will often relieve the retention, and repeated washings with a warm solution of 4 per cent sodium citrate through a catheter of wide bore sometimes remove the clot; more effective is to evacuate the clot via the sheath of a cystoscope, through which suction can be applied. Alternatively, a Bigelow's evacuator can be employed.

Blood-clot in the bladder is certain to become infected.

If the source of the bleeding is known, and it is estimated that there is a considerable amount of clot in the bladder, it is best to evacuate the clots by suprapubic cystostomy. This avoids decomposition of the blood and the attendant dangers of purulent cystitis.

RETENTION DUE TO ACUTE URETHRITIS OR PROSTATITIS

If the retention is unrelieved by morphine and a hot bath, even to attempt to pass a urethral catheter is to contravene surgical principles. Suprapubic catheterization should be performed.

RETENTION OF URINE IN THE FEMALE

This is comparatively rare.

Incarcerated Retroverted Gravid Uterus is the most important cause of sudden inability to empty the bladder. The incarceration occurs about the fourteenth week of pregnancy and is caused by the fundus of the enlarging uterus becoming entrapped beneath the sacral promontory of an unusually concave sacrum. Retention from this cause is more serious than a corresponding overdistension of the bladder caused, for instance by an enlarged prostate, for the distension arises so suddenly that the bladder has no opportunity *to accommodate itself to its greatly increased burden by muscular hypertrophy*. Consequently hæmorrhage from, and sometimes necrosis of, the vesical mucous membrane is liable to occur. Should infection follow, the result is always serious, and perforation of the bladder is not unknown.

Diagnosis.—It should be known that the usual complaint is not of inability to pass urine, but of abdominal pain and increased frequency or dribbling due to overflow. The diagnosis should spring to mind when a large cystic swelling arising out of the pelvis is discovered, and vaginal examination reveals a high cervix pointing forwards. If the patient has not volunteered the information that she is pregnant, her menstrual history must be questioned closely. Even if the swelling is mistaken for a twisted ovarian cyst, surely one would think the diagnosis would always become apparent when the patient was catheterized in the anæsthetic room, but not so. Chassar Moir has heard of a case where the abdomen was opened, the bladder wounded, urine gushed forth, and death resulted.

Treatment.—The correct treatment is to pass a self-retaining catheter—the urethra is unusually long in these cases—and after emptying the bladder, to clip the catheter and strap it to the thigh as high as possible; then proceed to evacuate the bladder contents at least every two hours. As soon as she is comfortable the patient is instructed to lie on her side or, better, in a semi-prone position, and often the uterus rectifies itself. When this does not occur 24 hours later, with the patient in the knee-elbow position, gentle pressure should be exerted on the body of the uterus as near to the fundus as possible by a finger inserted into the rectum. If digital reposition is unsuccessful, a large ring pessary should be inserted. Often the constant pressure of the ring causes disimpaction of the fundus from beneath the sacral promontory. In most exceptional instances laparotomy must be performed to disimpact the uterus held in the retroverted position by adhesions.

An Impacted Uterine Fibroid, usually cervical in origin, can cause retention of urine (see p. 500).

An Ovarian Cyst impacted in the Pelvis, or Pelvic Hæmatocele are rare causes of acute retention of urine.

Childbirth is a very common cause of retention of urine, and is one that is frequently overlooked, the associated pain being ascribed to after-pains, and the distended bladder being mistaken for subinvolution of the uterus. The retention is due to bruising of the bladder neck, and is probably a temporary neuromuscular derangement, rather than a mechanical obstruction due to œdema. A self-retaining catheter should be inserted, and the bladder emptied in the manner described above. The catheter should be retained for at least 48 hours.

Hysteria is often cited as a cause of urinary retention in the female. It is probably very uncommon, and every other cause must be eliminated before this diagnosis is assumed.

ACUTE RETENTION OF URINE DUE TO DRUGS OTHER THAN SEDATIVES

A number of the newer drugs are prone to induce or precipitate retention of urine. Methantheline banthine bromide, used to decrease secretion and motility in peptic ulcer, is very likely to produce retention of urine in patients with prostatic enlargement. Antihistamine drugs, antihypertensive drugs, anticholinergic drugs (belladonna; probanthine),

and isonicotinic acid hydrazine compounds (chemotherapeutic agents for tuberculosis) have all been responsible for producing acute retention, and the surgeon should be cognizant of drug retention

RETENTION OF URINE FOLLOWING INJURY OF THE SPINAL CORD[1]

Physiology.—The maintenance of the postural tone of the bladder is a function of the intramural nerve plexus, and is not influenced directly by extravesical nerve lesions. Contrary to traditional teaching, the bladder does not become atonic after a complete lesion of the spinal cord unless overdistension is allowed to occur

Micturition is a spinal reflex action, mediated by the third and fourth sacral segments and controlled by descending inhibitory impulses (*Fig* 860) For practical purposes the sympathetic innervation may be ignored, apart from the sensation of overdistension that it conveys these impulses reach the cord at a level as high as the sixth thoracic segment.

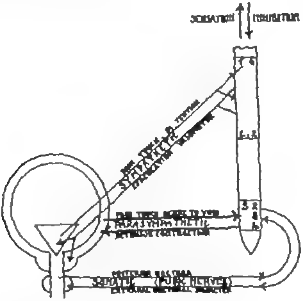

Fig 860.—The mechanism of nervous control of the bladder

Conus or Cauda Equina Injuries.—In lesions of the terminal conus or cauda equina involving the third and fourth sacral segments or roots, emptying contractions of the bladder are abolished, but the external urethral sphincter is also paralysed however the abdominal muscles retain their power so that the stage is set for expression of urine by abdominal straining or manual compression. A short period of retention is usual lasting until such time as the patient is able to master the technique required. Sympathetic sensation usually enables the patient to judge when his bladder becomes full, and efficient emptying with complete continence can often be achieved.

The onset of retention in such a case is a surgical emergency from the urological point of view at least. If the damage is incomplete and remediable (as in the case of a prolapsed intervertebral disk), surgical decompression of the lesion performed within a few hours will probably relieve a bladder paralysis which would otherwise be permanent.

Injuries above the Sacral Segments.—In injuries above the third and fourth sacral segments of the cord, there is a period of retention of urine (which may last for many months) associated with that abolition of distal reflexes known as spinal shock. Uncontrolled spinal reflex emptying ultimately returns provided the bladder remains healthy and the general condition of the patient good. Imperfect voluntary control is often established in an incomplete lesion and sometimes in cases of partial recovery after a complete lesion.

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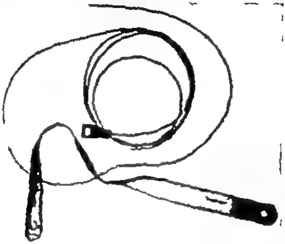
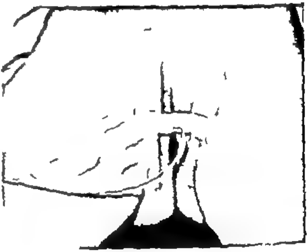
[1] Written by N. G. K. Gibbon, Ch.M. Liverp., F.R.C.S. Eng. et Edin.; Assistant Surgeon Walton Hospital Liverpool.

Management.—In the case of acute injury to the cord or cauda equina the bladder becomes distended until it overflows. Pain is rare except in partial lesions, and the distension does not necessarily interfere with the subsequent development of efficient emptying by reflex contraction or expression. The overflowing urine can be collected easily in the male so preventing soaking of the bed and maceration of the skin. Only in the female paraplegic is early vesical drainage imperative. There are many male cases on record in which non intervention has been followed by satisfactory bladder emptying,



A

B



C

Fig. 880.—A, The Gibbon catheter; B, Catheter in place in the male; C, Catheter in place in the female.

the urine having remained sterile throughout. I mention this in order to emphasize that unless aseptic drainage can be guaranteed, it may be wiser to abstain from any instrumentation. In cauda equina lesions, sometimes from the very commencement of the retention the urine can be expressed by gentle manipulation of the bladder aided, perhaps, by a finger in the rectum.

It is currently accepted, however that prolonged vesical overdistension is liable to damage the detrusor and that drainage should be instituted as soon as conditions permit of this being done aseptically. It should often be possible to wait until the patient has been transferred to a spinal injury centre. Judicious use of suprapubic aspiration is helpful in the female and in patients suffering pain.

An indwelling urethral catheter is satisfactory for routine use *provided the catheter used is non irritant and of small calibre.* A latex rubber catheter of the Foley type of a size not greater than 14 F., is recommended With the use of such a catheter (or of a finer polyvinyl catheter (*Fig* 800) which is employed at the Liverpool Regional Spinal Injuries Centre) urethritis is minimized and there is seldom need for suprapubic drainage. If this is required however the suprapubic catheter should be introduced with an instrument such as that devised by E. W Riches (see p 645)

In all cases the catheter should be connected by sterile tubing to a sterile bottle, the system being closed *apart from an air vent in the stopper of the bottle.* A rubber catheter should be changed once or twice a week, opportunity being taken to irrigate the urethra. A daily bladder wash-out is advisable when mucus or phosphatic debris is detected in the urine 1–2000 bradosol is employed for routine irrigations and 0 5 per cent acetic acid when there is evidence of phosphatic encrustation of the bladder or the catheter The irrigation is best accomplished by the skilful use of a bladder syringe otherwise an irrigating reservoir is connected by a Y tube to the closed drainage system and released intermittently

A high fluid intake should be insisted upon, and a urinary antiseptic is administered prophylactically *A safe urinary antiseptic to employ is urolucosil,*[1] *250 mg six hourly* as there is little risk of crystalluria, even when it is given for many weeks.

Intermittent Catheterization has been revived successfully at the National Spinal Injuries Centre at Stoke Mandeville. With the intermittent method serious complications can be avoided only by the unremitting attention of skilled personnel. The method is fraught with danger in inexperienced hands, as pyelonephritis soon follows if an infected bladder is allowed to become overdistended.

The management of the paraplegic bladder in the later stages is not within the province of this book. Suffice it to say that it is a difficult exercise in applied physiology and a rigorous test of surgical judgment and technique As such, it lies properly within the sphere of the specialized staff attached to a Spinal Injuries Centre, and should not be embarked upon by anyone who lacks the necessary experience

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[1] William R. Warner & Co Ltd. Power Road, London W 4

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CHAPTER LVII

THE PROSTATE AND SEMINAL VESICLES

Hæmorrhage after Prostatectomy.—During the first 24 hours after retropubic prostatectomy with closure of the bladder or transurethral resection, stoppage of the flow of (blood-stained) urine due to a small clot occluding the urethral catheter is not unusual. This must be cleared by alternately introducing 1 oz. (30 ml.) of flavine solution and sucking it out with a well-fitting piston-type bladder syringe. Care must be taken not to introduce air into the bladder. If these irrigations are carried out soon after the catheter becomes blocked, the clot can not only be dislodged but evacuated.

The incidence of severe hæmorrhage is low after operations which allow bleeding points to be ligated; reactionary hæmorrhage is highest after the Freyer operation, while secondary hæmorrhage (due to separation of slough) is more likely to occur after transurethral resection with the diathermy loop. Should severe hæmorrhage recur at intervals of several days after adenomatous tissue has been enucleated, the possibility that a piece of adenomatous tissue has been left behind must receive careful consideration.

Reactionary Hæmorrhage.—When, following prostatectomy, hæmorrhage is greater than would be expected, the following measures are imperative:—

1. A quarter of a grain (16 mg.) of morphine is given at once.
2. The pulse-rate and blood pressure are recorded at two-hourly intervals on a special chart.
3. Blood transfusion is commenced as soon as matched blood has been procured.
4. Because of the danger of supervention of infection, prophylactic antibiotic therapy is administered. If the urine proved sterile on previous examination, penicillin is given. In other circumstances an antibiotic suited to the bacteriological findings will be chosen.
5. Bladder irrigation is all-important. The bladder is irrigated with not more than 3 oz. (90 ml.) at a time of 1–10,000 silver nitrate solution. It is a moot point whether these bladder washes should be given hot (the temperature of the solution in the receptacle must never exceed 110° F. (43° C.)). It is a time-honoured belief that the heat of the fluid helps to stay the hæmorrhage. Nevertheless, it can be argued reasonably that the heat provokes vasodilatation, thereby favouring hæmorrhage. For this reason, lotion at blood heat is recommended.

The irrigations are repeated, and the empty syringe is used to apply suction, which aids in the evacuation of small clots. If the presence of larger clots in the bladder is suspected, a warm solution of 4 per cent sodium citrate is valuable in breaking up very recent clot. When, apparently, all clot has been evacuated, irrigation with silver nitrate solution is recommenced.

Foley's Hæmostatic Bag Catheter (*see Fig.* 856, p. 633). If the catheter inserted at the time of the operation was not a Foley's, and the above measures have failed to stay

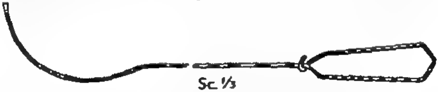

Fig. 891.—Introducer for a Foley's catheter.

the hæmorrhage, or a blocked catheter cannot be unblocked, the original catheter should be removed and a Foley's catheter substituted.[1] The best type of bag catheter for this purpose is one with a special irrigating channel as well as an inflation limb, but any type

[1] In some cases, particularly after retropubic prostatectomy, it is impossible to insert a Foley's catheter. When this contingency arises the patient should be taken to the operating theatre and if, with further irrigations and evacuation of clot through another type of catheter, the hæmorrhage cannot be controlled satisfactorily, the prostatic cavity should be packed.

of Foley's catheter is better than none. If the unstiffened Foley's catheter cannot be passed into the bladder it must be inserted while stretched on an introducer (*Fig* 891)

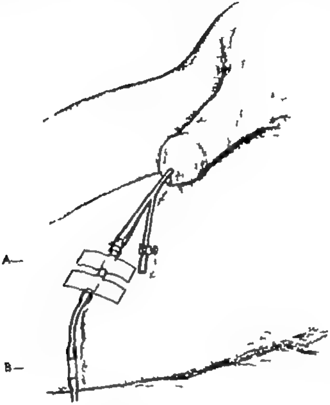

Fig 892.—Traction on the catheter is maintained by the glass connexion (A) being fixed to the thigh with strapping. By disconnecting the rubber tube at B, irrigations can be carried out without disturbing the bag in the prostatic cavity. If the catheter is fixed as shown the patient can flex the knee without releasing the tension on the catheter

Before inserting the Foley's catheter procure a glass syringe that will fit the inflation limb of the catheter tightly and, with water fill the bag to capacity without overstretching it. Allow the water to run into a measuring glass, and note the amount. Pass the sterilized catheter into the bladder and fill the bag with the measured amount of water stained deeply with methylene blue. Apply a screw clamp tightly below the expanded end of the inflation tube, or tie a tight ligature around it in the manner shown in *Fig* 916 p. 672. The methylene blue is to aid early recognition of a burst bag—not a very unusual happening. The next, and most important, step is to apply traction to the catheter so that the distended bag is withdrawn into and kept within, the prostatic cavity.

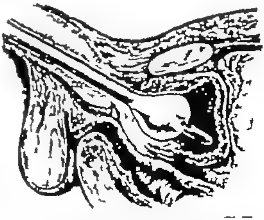

Fig 893.—Foley's bag catheter in the prostatic cavity. Traction on the catheter causes sufficient compression on the walls of the cavity to stop moderate hæmorrhage

Requirements.—Two glass connexions that will fit the catheter, a piece of rubber tubing 4 in. (10 cm.) long that will fit the connexions, and a long piece of similar tubing leading to a drainage bottle are assembled as shown in *Fig* 892.

Maintaining Traction.—While the catheter is being pulled gently an assistant fixes the proximal glass connexion (A) to the thigh with two strips of adhesive tape thus achieving tension without obstructing the outflow. To permit intermittent irrigation of the bladder without disturbing the bag in the prostatic cavity (*Fig* 893) the glass connexion

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5. Bladder irrigation is all important. The bladder is irrigated with not [more than] 3 oz. (90 ml.) at a time of 1–10 000 silver nitrate solution. It is a moot po[int whether] these bladder washes should be given hot (the temperature of the solution in the [syringe] must never exceed 110° F. (43° C.)). It is a time-honoured belief that the heat o[f the solution] helps to stay the hæmorrhage. Nevertheless, it can be argued reasonably that [heat] provokes vasodilatation, thereby favouring hæmorrhage. For this reason, lot[ion without] heat is recommended.

The irrigations are repeated, and the empty syringe is used to apply suctio[n, which] aids in the evacuation of small clots. If the presence of larger clots in the [bladder is] suspected a warm solution of 4 per cent sodium citrate is valuable in breaking [up the] recent clot. When, apparently, all clot has been evacuated, irrigation with silver [nitrate] solution is recommenced.

Foley's Hæmostatic Bag Catheter (*see Fig.* 850, p. 635). If the catheter inser[ted at] the time of the operation was not a Foley's, and the above measures have failed t[o control]

Fig. 891.—Introducer for a Foley' catheter

the hæmorrhage or a blocked catheter cannot be unblocked, the original catheter sh[ould] be removed and a Foley's catheter substituted.[1] The best type of bag catheter for [this] purpose is one with a special irrigating channel as well as an inflation limb, but any t[ype ...]

[1] In some cases, particularly after retropubic prostatectomy, it is impossible to insert a F[oley's] catheter. When this contingency arises the patient should be taken to the operating theatre if, with further irrigations and evacuation of clot through another type of catheter, the hæmorrh[age] cannot be controlled satisfactorily, the prostatic cavity should be packed.

(B in *Fig* 892) is disconnected from the short rubber tube As a rule these expedients control hæmorrhage from the prostatic cavity

Renewed Hæmorrhage.—Should serious renewed bleeding occur it is best to transfer the patient to the operating theatre where especially at night, in the good light it is less difficult to ascertain if the bleeding is progressive or not.

If the Foley s Catheter is, or becomes, blocked with Clot.—Usually it is necessary to remove the catheter for the walls of a Foley's catheter are insufficiently rigid to permit

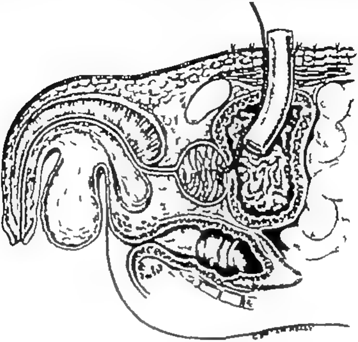

Fig 894 —The pa king of the prostatic cavity completed.

piston suction with a bladder syringe Having removed the catheter insert any type of more rigid catheter with a large eye and attempt to remove clots by irrigation and suction. In this connexion attention is drawn to the inestimable value of passing the cannula of a bladder evacuator such as Bigelow's, and evacuating clot in the same way as a fragmented vesical calculus is removed after litholapaxy If after either of these procedures, the hæmorrhage seems to have stopped, it may be good judgment to reinsert a Foley s catheter inflate the bag apply traction, and irrigate the bladder for a quarter of an hour Should irrigations be returned tolerably clear the patient is returned to bed.

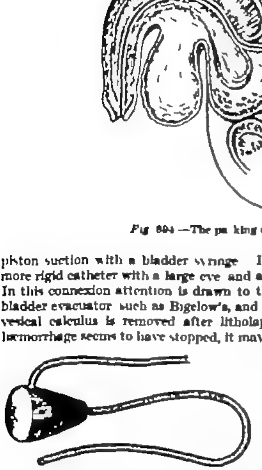

Fig 895 —Pilcher s bag The inflating limb i brought out of the suprapub c incision.

When the bleeding proves to be progressive, more radical steps must be taken.

Packing the Prostatic Cavity—The patient is anæsthetized. Suprapubic cystostomy is performed, or the suprapubic bladder incision is reopened, as the case may be. Blood-clot is evacuated and the bladder is irrigated. The prostatic cavity is packed at first with a small quantity of oxycel absorbable gauze and then with 1 in. (2 5 cm.) ribbon gauze to the end of which is tied a piece of silk, to aid removal of the packing (*Fig* 894) The bladder is closed around a large drainage tube, and when the patient is back in bed the bladder is kept empty by sump drainage (see p. 189).

Alternatively Pilcher s bag (*Fig* 895) can be inserted, and the bag distended with water This bag being made of stout rubber it is possible to exert considerable traction without fear of the bag bursting Traction is effected by tying a piece of silk to the end of the tubing, carrying the silk over the rail of the bed and attaching a 8 oz. (90 G) weight to it. While the bag is in position all the bladder urine is evacuated by suprapubic sump drainage

The packing or the bag is removed four or five days later

SPECIAL CONSIDERATIONS

Excessive Bleeding through the Prevesical Drain after Retropubic Prostatectomy.—When excessive hæmorrhage occurs after retropubic prostatectomy the bleeding often takes place not into the bladder but into the prevesical space, and from thence it manifests itself through the tube draining that space. In these circumstances the wound should be reopened and if the bleeding is seen coming from the capsular suture line, the bleeding area is under run with one or more sutures. Alternatively resort can be made to packing the prevesical space, but this is less desirable.

Bleeding after Transurethral Resection of the Prostate occurring within 48 hours of the operation usually can be checked by traction on the Foley's catheter and frequent irrigation of the bladder. When these measures fail, the patient should be taken to the operating theatre, and after evacuation of clots the bleeding points are visualized with the resectoscope, and coagulated. Rarely is suprapubic cystostomy and packing of the prostatic bed necessary.

Secondary Hæmorrhage due to Sloughing is relatively common after transurethral resection of the prostate, especially if a large hypertrophy has been resected. Hæmorrhage usually occurs during the second post-operative week, when the patient is becoming convalescent. If the bleeding is comparatively slight, often it can be controlled by emptying the bladder with a catheter, withdrawing clots by suction after small irrigations, and leaving in a Foley's catheter to which traction is applied. When the hæmorrhage is more severe and is not controlled by these measures the patient should be taken to the operating theatre and anæsthetized. Sometimes it is possible to coagulate the bleeding points through a resectoscope. Should this prove impracticable, suprapubic cystostomy must be performed and the prostatic cavity packed.

Blood-clot in the Bladder.—When, after a hæmorrhage, the urine remains discoloured pink for several days, it is of course possible that slight hæmorrhage is continuing. Another possibility is that there is blood-clot in the bladder and the urine becomes discoloured by contact with the clot. The best course in these circumstances is to assume that both possibilities are present. The first is cared for by keeping traction on a Foley's bag; the second is the more menacing, for blood-clot in the bladder will certainly become infected and putrefy no matter what concentration of antibiotic is present in the urine; antibiotics cannot penetrate lifeless clot. Irrigation of the bladder with a solution containing 100,000 units of streptokinase and 25,000 units of streptodornase (see p. 140) every 4–6 hours greatly helps to dissolve clot. The Foley's bag, pressed against the vesical neck, will prevent these enzymes coming into contact with the clot occluding the mouths of blood vessels in the prostatic bed, where such enzymic action might cause renewed hæmorrhage.

Recurrent Hæmorrhage, by which is meant that bleeding recommences after everyone concerned is certain that it has ceased, is often due to a fragment of enucleable prostate remaining in the prostatic bed. I have encountered a case in which bleeding recurred no less than five times, and was treated by the methods described. On the fifth occasion, under gas and oxygen anæsthesia, a small piece of prostatic tissue was found and removed and a Pilcher's bag was inserted. With further blood transfusions, the patient recovered.

RUPTURE OF THE PROSTATE

Because of its sheltered position, rupture of the prostate is exceedingly uncommon.

An effeminate man, aged 20, was admitted with severe rectal and perineal pain and slight hæmaturia. He stated that six hours previously he had been to a party and one of the guests was "very rough with him". No abnormality was detected on physical examination until a rectal examination was made. The anus was patulous, and where the prostate should lie there was a large cystic tender swelling.

Operation. A perineal incision was made and by sharp and blunt dissection it was deepened upwards and backwards to the region of the prostate. Suddenly there was a gush of about ¼ pt. (140 ml.) of blood, and in the blood there was a piece of the prostate. The wound was closed with drainage. No complication ensued.

ACUTE PROSTATITIS

It is difficult, if not impossible, to separate infections of the prostate gland from those of the seminal vesicles; indeed, in 80 per cent of cases the condition is, in fact, an acute prostato-seminal vesiculitis. The infection is sometimes hæmatogenous; more often it is retrograde

Diagnosis.—As a rule there is considerable elevation of temperature, and the patie feels ill A persistent aching in the perineum, accompanied by pain on defecation, is t characteristic local symptom. When the infection follows urethritis, including eithe *urethritis (see p. 641), the diagnosis presents no difficulty and in all instances* it becom unmistakable when an enlarged, acutely tender hot prostate is felt on rectal examinati In no circumstances whatsoever must the prostate be massaged in the attempt to obt a specimen of purulent fluid for bacteriological examination. A two- or three-glass t should be performed, and clear followed by cloudy urine is extremely suggestive. T specimen should be sent for bacteriological examination. Especially when the infect appears to be blood borne, it is advisable to send a specimen of blood for culture.

Treatment.—The patient should be kept strictly in bed. The urine is rende alkaline with a citrate mixture (*see* p 573), to which Tinct. hyoscyami is added. Af an enema has been given, suppositories of morphine and ichthyol are often soothing I Sitz baths are helpful. While awaiting the bacteriological report on the urine penici and streptomycin, or aureomycin, can be given. At the present time the bacteria m often responsible for acute prostatitis are *Esch. coli* a staphylococcus that is not infreque penicillin-resistant, and an antibiotic-resistant gonococcus. Especially if specific a biotic therapy can be given, the prognosis is excellent. Occasionally the main infect organism is proteus or *Pseudomonas aeruginosa*, which are resistant to the more u antibiotics. The organism cultured from the urine is not necessarily the one causing prostatitis therefore if one antibiotic fails to control the infection another (e.g r mycin) must be substituted always being mindful that the usual cause of failure conservative treatment is the development of a prostatic abscess.

When the acute symptoms have abated for a week, the prostate and seminal vesi should be massaged, and the resulting specimen examined bacteriologically In necess cases the treatment for chronic prostatitis must be commenced and continued until signs of infection have disappeared.

PROSTATIC ABSCESS

As would be expected, since the advent of sulphonamides and antibiotics, the incide of prostatic abscess has declined steeply with the result that in recent years there has b a liability to overlook the condition until retention of urine has supervened. Prost abscess can occur at any time during adult life, and contrary to days gone by when m prostatic abscesses (resulting from gonorrhoeal prostatitis) were seen in young mer rather high proportion of these patients are elderly

At the present time the organisms most often responsible for a prostatic abscess *Esch. coli* or a penicillin-resistant staphylococcus.

Diagnosis.—The differentiation between acute non-suppurative prostatitis prostatic abscess can be very difficult. Urgency increased frequency and dysuria the most usual symptoms in both conditions. Typically the advent of a prostatic abs is heralded by a steeper rise of temperature than was registered during the stage prostatitis, and rigors are not unusual—but the early administration of an antibiotic o disguises these leading symptoms. Severe, unremitting perineal and rectal pain, occasionally associated with tenesmus, should direct the clinician's thoughts to the probability of prostatic abscess. Too often the nature of the pain, and particularly its localization, leads to confusion with pararectal suppuration. A digital examination of the prostate will obviate this mistake, for the gland will be found to be enlarged, often asymmetrically hot, and extremely tender If an area of softening can be felt in the prostate, the diagnosis is certain. Nevertheless, what is extremely important to know is that a tense, exquisitely tender enlargement of the prostate is liable to disguise the presence of an abscess, because no area of softening can be elicited. In these circumstances on no account should fluctuation be awaited.

Untreated, if a prostatic abscess does not burst into the urethra, it frequently does so into the perirectal tissues or the perineum. Rupture into the rectum is a calamity for so often a rectovesical fistula results, and such a fistula is most difficult to close

A brief period of illness does not rule out the possibility of prostatic abscess In L. Persky's series many patients had had symptoms for less than a week. Especial attention is directed to the frequency with which diabetic patients with prostatitis

develop a prostatic abscess which, if not drained early, is liable seriously to endanger the patient's life. In all suspected cases culture of the urine and the blood should be undertaken when possible.

Treatment.—The continued administration of antibiotics in the presence of a prostatic abscess is useless. As soon as the diagnosis has been made, the abscess should be drained without delay. It is true that if a catheter is passed to relieve acute retention of urine sometimes the abscess is ruptured into the prostatic urethra with amelioration of symptoms. However such drainage is insufficient in the majority of cases: intractable chronic prostatitis follows, and the development of a further abscess is not unusual.

Operation.—Of several methods of draining the abscess, the following will be found to be the most satisfactory, and it does not require special instruments such as a prostatic tractor. The anæsthetized patient is placed in the exaggerated lithotomy position, and an incision 1½ in. (4 cm.) in length is made 1 in. (2.5 cm.) in front of the anus (*Fig.* 896) on to a metal bougie introduced from the external meatus. The urethra having been opened the bougie is removed. Hæmostasis is effected as described in the section on perineal urethrostomy (*see* p. 647). A finger is introduced through the incision into the prostatic urethra, and then through the posterior urethral wall into the abscess cavity. If this is found to consist of several pockets, intervening septa should be broken down. The finger is withdrawn, and a rubber catheter—preferably a Foley's—is passed into the bladder through the wound, and anchored to one side of the posterior end of the skin incision. The anterior part of the wound is approximated loosely, and a dry dressing is applied.

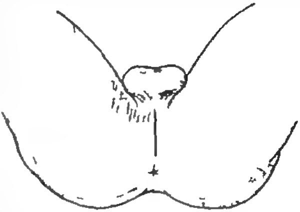

Fig. 896.—Incision for opening a prostatic abscess.

After-treatment.—The catheter should be left in for six or seven days. Drainage of the abscess is followed by immediate relief of pain and early subsidence of the accompanying pyrexia, extracapsular contiguous extension of the suppurative process is prevented, and chronicity is minimized.

The patient should be observed for some months, with a view to treating chronic prostatitis, if such persists.

ABSCESS OF A SEMINAL VESICLE

While infection and suppuration of the seminal vesicles is common, abscess formation is rare. A few cases of bilateral abscesses have been reported, but as a rule the condition is unilateral.

Diagnosis.—In addition to the usual signs of prostatitis, pain is sometimes referred to the small of the back, the suprapubic region, and down the inner side of the thighs. It is possible for a large abscess of a seminal vesicle to be present without constitutional symptoms, especially if the patient has been treated by antibiotics. On rectal examination the vesicle is found to be greatly enlarged, tender and hot. On no account must an attempt be made to evacuate the contents of the abscess down the common ejaculatory duct by pressure on the vesicle.

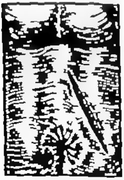

Fig. 897.—Incision for draining an abscess of the left seminal vesicle.

Operation.—The patient is placed in the exaggerated lithotomy position. An incision is made over the medial part of the ischiorectal fossa as shown in *Fig.* 897. By blunt dissection the incision is deepened until the fusiform swelling is felt unmistakably. A long hæmostat is then thrust into the abscess cavity, and its jaws are opened, liberating the pent-up accumulation of purulent fluid. The wound is closed lightly around a drainage tube passed into the abscess cavity.

ACUTE COWPERITIS

The bulbo-urethral glands of Cowper, situated between the layers of the triangular ligament, are from time to time the seat of acute inflammation, which is often mistaken for prostatitis or seminal vesiculitis. When abscess formation follows, too often the very existence of these glands is not thought of and the diagnosis of ischiorectal or periurethral abscess is made. The chief symptom of Cowperitis is pain in the perineum; the pain is not so severe as that of acute prostatitis, and it is not referred to the rectum. Tenderness on one or other side of the midline of the perineum anteriorly is very suggestive. On rectal examination the prostate and vesicles are likely to be affected. Still retaining

Fig. 898.—Method of palpating Cowper's glands.

the finger in the rectum, each Cowper's gland is palpated by placing the thumb first on one side and then on the other of the median raphé of the perineum (*Fig.* 898). If the inflammation does not subside with rest in bed, Sitz baths, and antibiotic therapy and the swelling is enlarging, drainage is necessary.

A retired major, aged 62, had great pain and swelling in the perineum two weeks before admission. He was given sulphanilamide therapy. The pain, though less severe, continued, and the swelling enlarged. On examination there was a very large perineal abscess to the left of the middle line. A diagnosis of abscess of Cowper's gland was made.

The skin overlying the abscess was excised, and the lining membrane of the cavity, which was the size of a goose's egg, was abraded with gauze. The wound was packed with gauze soaked in flavine. The wound healed well. *Culture of the pus disclosed Staphylococcus albus and a* diphtheroid bacillus.

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CHAPTER LVIII

THE URETHRA

RUPTURE OF THE URETHRA[1]

Rupture of the urethra is one of the most serious accidents and unless your skill can prevent the development of a stricture you are presiding at the opening of a lifelong tragedy (Rutherford Morison.)

Every rupture of the urethra even the slightest is a potential stricture . (Boeckel.)

RUPTURE OF THE BULBOUS URETHRA

The triad of signs and symptoms of a ruptured bulbous urethra is (1) Urethral hæmorrhage (2) A perineal hæmatoma and (3) Retention of urine. To these may be added a fourth—pain.

Urethral hæmorrhage (*Fig* 899) is certainly good evidence that the mucosa is involved but its profusion is no guide to the severity of the rupture. I saw a patient who three

Fig 899.—Complete rupture of the bulb of the urethra. Blood is trickling from the meatus. The patient had fallen astride a few hours before the photograph was taken.

days previously had stepped on to the lid of a pavement coal hole which was not securely in place, with the result that one leg went down into the cellar whilst the perineum bore the brunt of the fall. For three days severe urethral hæmorrhage had continued and owing to this the patient was profoundly anæmic yet an exploring catheter slipped readily into the bladder

Perineal hæmatoma (*Fig* 900) is always in evidence but its size is no guide to the extent of the mucosal tear It is quite clear that the bulb of the corpus spongiosum may be severely damaged and its ensheathing envelope broken whilst the mucous membrane remains unharmed.

Retention of urine is due to a reflex spasm of the compressor urethræ. Proof of this is afforded by the fact that the bladder is sometimes emptied as soon as the patient is anæsthetized fully This spasm of the compressor prevents extravasation for many hours (see *Fig* 906)

If the bulbous urethra has been ruptured, it is most necessary to know whether the rupture is complete or incomplete Yet it must be realized that there is no absolute

[1] This accident other than as an obstetrical complication is almost unknown in the female

necessity to obtain this information immediately. The practice of passing or attempting to pass a catheter with only ordinary precautions, and the mild infection of the lacerated tissues which ensues thereby account for many traumatic urethral strictures.

Fig. 900.—Rupture of the bulb of the corpus spongiosum with extravasation of the blood into the scrotum. In spite of the magnitude of the hæmatoma, the rupture of the urethra was incomplete.

Promiscuous catheterization must be abolished. The catheter can be withheld even in the direst emergency under the most extenuating circumstances. A case of what proved eventually to be complete rupture of the urethra occurred on board ship four days out from Havre. Catheterization was not attempted, retention being relieved by repeated suprapubic punctures until the ship reached port, when the patient was transferred to hospital. Extravasation did not occur. (G. Marion.)

Rupture of the Bulbous Urethra without Extravasation.—The best way to proceed is as follows. Forbid entirely any urethral instrumentation and tell the patient not to try to pass urine. Administer 500,000 units of penicillin and a suitable dose of morphine, after which arrange for the pubes to be shaved.

The patient is brought to the operating theatre. Cleanse the penis and wash out the anterior urethra several times. Introduce a lubricated soft rubber catheter through the meatus and pass it down the urethra. If the catheter passes without difficulty into the bladder, obviously the lesion is incomplete. Distend the bladder with lotion and permit it to run out into a receptacle before removing the catheter.

If the tip of the catheter is arrested in the bulb and bleeding is provoked, there is a complete rupture.

In either case wash out the urethra once more before proceeding further. At this stage a general anæsthetic is administered.

Incomplete Rupture.—Perform suprapubic cystostomy (see p. 631). A small de Pezzer type of catheter is used to drain the bladder—small, because when it is removed the cystostomy wound will close more quickly.

Complete Rupture.—As in the above instance, the first step is to perform suprapubic cystostomy under local anæsthesia. The bladder having been opened, a Lister's sound is introduced down the internal urinary meatus. A liberal supply of gauze is wrapped round the sound, and this forms an excellent protection to the wound during subsequent manœuvres. (*Fig.* 901.) A towel is then placed over the gauze and the bougie, leaving the handle free for an assistant to hold. The patient is now moved into the lithotomy position.* Two Lane's tissue forceps are clipped upon the scrotum. By passing a long loop of bandage through the handles, the anæsthetist at the head of the table can retract the scrotum upwards. A very important

Fig. 901.—A bougie has been passed into the internal urinary meatus. The handle is held by an assistant, whilst a plentiful supply of gauze wrapped around the shank protect the suprapubic wound during the perineal stage of the operation.

* If Lloyd-Davies's stirrups are available it is possible to place the patient in a position that will obviate the necessity of changing the position during the operation.

detail is to have the perineum shaved and the skin disinfected thoroughly It is quite impracticable to have this attended to at an earlier stage of the proceedings. All this time an assistant has been holding the Lister's sound in the posterior end of the urethra. A gum-elastic bougie is now passed from the external meatus to the site of the rupture and the assistant holds this bougie in position also Towels are draped around the area An incision is made in the middle line of the perineum from the base of the scrotum to within ¾ in. (1 8 cm.) of the anus. Blood and blood-clot are removed, and spurting vessels are ligated. The incision is deepened until the urethra is opened.

Both ends of the urethra are at once accessible. The assistant is requested to remove the gum-elastic bougie and to withdraw the metal bougie until its tip is conveniently out of the field of operation. The roof of the urethra is sutured by interrupted catgut stitches

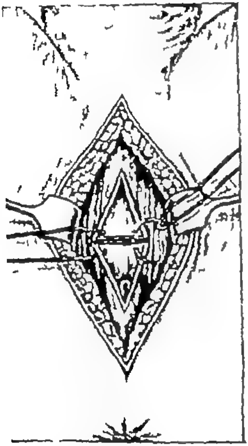


Fig 902.—Suturing of the roof of a completely ruptured bulbous urethra. Note the tip of the metal bougie in the proximal end of the exposed urethra.

Fig 903.—Mobilising the anterior end of the corpus spongiosum. (*After G Marion.*)

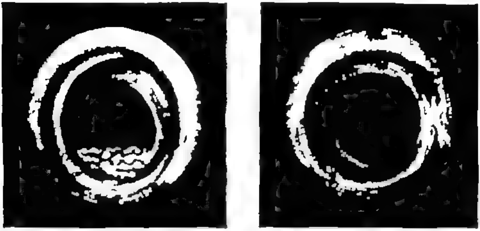
Fig 904.—Irrigation of the perineal wound with penicillin solution through a Higginson's syringe

(*Fig* 902) and, in order to avoid these cutting out a firm grip of the corpus spongiosum as well as the mucous membrane should be taken. After the suturing has been completed—two or three sutures suffice—the perineal wound is packed lightly with ribbon gauze soaked in acriflavine solution. Dressings having been applied, the patient is taken down from the lithotomy position. Attention is now directed to the suprapubic incision. The bladder is closed about a medium-sized Malecot catheter

Occasionally owing to their wide separation it will be found impossible to bring the divided ends of the urethra into appoition by the method detailed. This obstacle can be surmounted by mobilisation of the anterior end of the corpus spongiosum (*Fig* 903) an expedient that permits the divided ends of the roof of the urethra to be united without tension.

After-treatment.—The suprapubic catheter is connected to a closed-system drainage bottle (p. 640). The proximity of the perineal wound to the anus makes some infection almost inevitable and special precautions are needed to ensure healthy granulation, which

means so much in the prevention of stricture formation. To this end the bowels should be kept confined for the first four or five days. The administration of penicillin is continued, and sulphadimidine or sulphatriad is given by mouth. The perineal wound should be irrigated twice daily with a mild antiseptic solution (e.g. acriflavine 1–10 000) by means of a Higginson's syringe (*Fig.* 904), which has been found a trustworthy method. Irrigation should be commenced when the packing is removed 24 hours after operation and continued for a fortnight.



A B

Fig. 905.—Complete rupture of the bulbous urethra treated by suture of the roof. A, Urethroscopic appearance during the sixth week after operation. B, Three months later. An irregular scar is seen on the floor. A 17/19 bougie passes with ease.

Not until the twelfth or fourteenth day is it necessary to commence instrumentation. Before this is undertaken, the meatus should be cleansed and the urethra irrigated with a weak antiseptic solution. One well-lubricated Lister's sound is introduced, exercising the "rule of the bougie"—*non vis sed arte*—to its fullest degree.

Great stress must be laid upon the necessity for urethroscopic control (*Fig.* 905) in the after-treatment of cases of ruptured urethra. Only by repeated use of the urethroscope and post-operative urethrography (*see Fig.* 920) can the extent of the urethral scarring be determined. While the intervals between urethral dilatations can be extended gradually, it is essential that a bougie be passed occasionally. In many instances, eventually months can elapse between attendances, but it is most advisable for every patient who has sustained a complete rupture of the urethra to attend for occasional urethral dilatation for the remainder of his life.

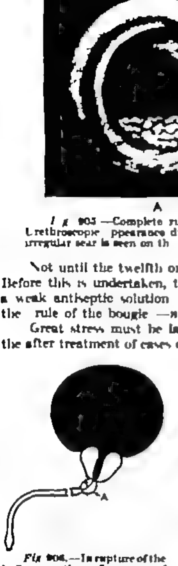


Fig. 906.—In rupture of the bulbous urethra reflex spasm of the compressor urethrae (A) prevents extravasation of urine for several hours.

Complete Rupture with Extravasation (*Fig.* 906).—*The sutureless operation* is without doubt *the* operation when extravasation has occurred, for suturing is technically impossible in the presence of infection or extravasation. If it is attempted under these conditions, the sutures simply cut out and add still further to the destruction and loss of tissues. A course of penicillin and streptomycin is commenced pre-operatively.

Technique.—Preliminary suprapubic cystostomy and retrograde bouginage are carried out as described previously. The patient is placed in the lithotomy position and perineal section is performed. A catheter, a Foley's catheter for preference, is passed from the external urinary meatus into the perineal wound, and from thence is threaded along the posterior urethra guided by the retrograde bougie, which is withdrawn slowly by the assistant as the catheter is advanced. The tip of the catheter is made to protrude through the suprapubic wound. By transfixion, a length of strong silk is attached to the catheter just below the terminal eye. The silk is left protruding from the suprapubic wound, so that in due course the catheter can be changed by the railroad method.

While the gap between the ends of the urethra may [illegible] considerable when the patient is in the lithotomy position, yet when the legs are [illegible] ably the ends of the urethra

will be in contact Once the catheter is in place if it is not a Foley's catheter it should be tied in by one of the approved methods. Suprapubic drainage of the bladder should be effected by a large drainage tube so that the bladder can be kept empty by suction drainage and the prevesical space should be drained adequately. Incisions are made into the infiltrated tissues as necessity demands.

After treatment.—Being of latex rubber if a Foley's catheter has been inserted, it need not be changed. In other circumstances the urethral catheter should be changed at the end of a week. The after treatment of the perineal wound is similar to that described on p. 677 The incisions leading into the extravasated area should be dressed with sterile gauze if non-infected, or if infected by the method described in the section dealing with extravasation following peri-urethral abscess (see p. 6**) In cases of extravasation of urine it is advisable to administer streptomycin in addition to penicillin and sulphatriad.

The suprapubic tube is removed at the end of 14 days. The urethral catheter is removed finally when the suprapubic and perineal wounds have healed. Further details concerning extravasation of urine are given on p. 674

INTRAPELVIC RUPTURE OF THE URETHRA

Intrapelvic rupture of the urethra is a more serious condition than the foregoing. The mortality is higher and the immediate diagnosis more difficult The lesion is almost always an accompaniment of a fractured pelvis, and shock is often pronounced.

In addition to a fractured pelvis, about half the patients will be found to have

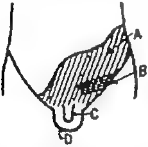


Fig. 907.—Physical signs recorded in a case of intrapelvic rupture of the urethra complicating a fractured pelvis. A, Deep-seated swelling (tender); B, Superficial bruising; C, Blood from meatus; D, Prominent cat. There was grating on compressing the iliac crests.

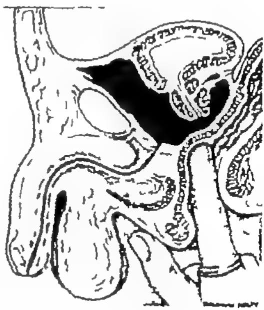


Fig. 908.—Intrapelvic rupture of the urethra. The prostate cannot be felt in its normal position.

sustained one or more other fractures. V. J. O'Connor found that the thigh or leg one or more ribs, the skull and a vertebra, in that order of frequency are the bones most frequently broken. Nor does this complete the list of major concomitant lesions. One must always be alive to the possibility of, and take precautions to exclude an additional intra-peritoneal lesion.

Diagnosis.—Signs of a fractured pelvis are usually but not always, evident on this account preliminary radiographs is most desirable The patient has not passed urine since the accident, and the escape of blood via the meatus is a common occurrence On examining the abdomen tenderness above the pubes in a conscious patient is always present. As a rule a swelling can be felt in the hypogastrium. Extravasation into the pelvic fascia occurs early and, curiously it usually proceeds more on one side than on the other (*Fig* 907) In this variety of rupture of the urethra there is no perineal swelling but ecchymoses may be present.

Differential Diagnosis.—When the rounded dome of the bladder can be palpated distinctly from the rest of the swelling (the extravasation) intrapelvic rupture of the urethra is probable If on rectal examination the prostate cannot be felt, but where the prostate should be there is an indefinite doughy swelling (blood and urine) (*Fig.* 908), or if the prostate is felt but is displaced upwards, and on exerting increased pressure upon

it it eludes the examining finger then the diagnosis of a complete intrapelvic rupture of the urethra is certain (Vermooten's sign). Unfortunately this sign is not present regularly In its absence it is desirable to confirm the diagnosis by cysto-urethrography

Cysto-urethrography will enable intrapelvic rupture of the urethra or extraperitoneal rupture of the bladder to be distinguished from lesions not requiring an immediate operation. The technique of cysto-urography is the same as that described on p. 625 but instead of the medium being introduced through a urethral catheter the injection is undertaken with a urethral syringe applied to the external urinary meatus, and films are exposed *while the medium is still being injected. In this way the urethra will be visualized.*

In intrapelvic rupture of the urethra the typical cystographic finding is a rising sun burst shadow representing extravasation below an intact bladder containing urine.

The Urethral Lesion.—Intrapelvic rupture of the urethra occurs frequently at the apex of the prostate—in other words, the prostatic urethra is severed from the membranous portion. In addition, the puboprostatic ligaments are torn. The loss of these ligaments, aided no doubt by the pressure of the extravasated products in the prevesical space causes the neck of the bladder with the prostate, to become displaced backwards (*Fig* 909). *Urine does not escape immediately because of the tone of the internal sphincter of the bladder*

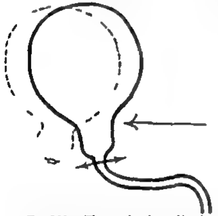


Fig 909 —The mechanism of backward displacement of the bladder The urethra having been severed near the apex of the prostate, and the puboprostatic ligaments having been torn, the pressure (arrow) of the extravasated product in the prevesical space causes the neck of the bladder to be displaced backwards.

While suprapubic cystostomy and drainage of the prevesical space commonly saves the life of the patient, it is essential to go further and make provision for restoration of the continuity of the urethra before it is too late. It is the backward displacement of the bladder neck that accounts for the poor results of remote restoration of continuity of the canal and if it is not rectified at the initial operation we are bound to meet with the following depressing aftermath :—

A patient presents himself with a suprapubic fistula. The sinus is unhealthy and discharging purulent urine. He may have been fitted with a permanent suprapubic belt, but the reason for his appearance is that the fistula has closed down and will not admit the catheter An examination of the perineum reveals an old scar and there is a history of a fractured pelvis, rupture of the urethra, suprapubic drainage, and drainage of the prevesical space. At a later date (usually when the fracture has united) an attempt—or more often several attempts—has been made to restore the continuity of the urethra, but without success. Continually wet and smelling of urine, subject to recurrent attacks of cystitis and pyelitis, these cases are poignant examples of what Rutherford Morison refers to so aptly as " lifelong tragedies "

These tragedies *can* be obviated, but only by correcting the backward displacement of the neck of the bladder before it becomes anchored in its abnormal position.

When intrapelvic rupture of the urethra has occurred, seldom can a catheter be passed into the bladder It is therefore impossible to divide these cases into incomplete and complete ruptures. There is, however little doubt that in many the continuity of the urethra is not broken completely (D S. Poole-Wilson).

Armamentarium.—For the correction of the backward displacement of the bladder neck and the prostate some form of catheter of the Foley type, which permits extension being applied to the neck of the bladder via the catheter is essential.

1 Foley's balloon-ended catheter is generally employed (*Fig* 910).

2. Pilcher's bag (*Fig* 911) is also excellent. Its strength is an advantage

3. Improvisation When neither (1) nor (2) is available, or the catheter or bag is too large to permit its use in a child, a soft rubber catheter after it has been passed in the way presently to be described, can be rendered suitable in the following way : the eyed end of the catheter is brought out of the suprapubic wound. Rubber dam[1] (lengths can be cut from a rubber glove) ¾ in. (1 8 cm.) wide is wound around the shaft of the catheter above the eyes, until there is a substantial collar The collar is made fast by transfixion

[1] Penrose rubber tubing, or small Paul's rubber tubing, is ideal for this purpose

with a silk ligature passed on a straight cutting needle. The ligature is then tied firmly first on one side and then on the other thus binding the collar It must be removed by pulling it head first through the cystostomy wound (Constantian and Felton).

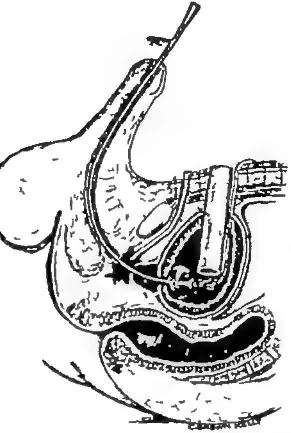


Fig 910 —Foley s catheter in place in a case of intrapelvic rupture of the urethra. Extension has not yet been applied to the catheter

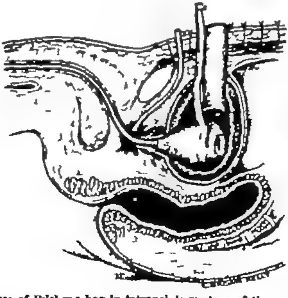


Fig 911 —The use of Pilcher s bag in intrapelvic rupture of the urethra. Extension has not yet been applied.

In addition to the special catheter Lister's sounds will be required. Before commencing the operation, select two of these sounds that should be commensurate with the size of the patient s urethra (13/15 and 14/16 for an adult). Have in readiness a long piece of rubber tubing that fits really tightly when milked on to the beak of the smaller of the two sounds.

OPERATION FOR INTRAPELVIC RUPTURE OF THE URETHRA

The importance of temporary immobilization of the fractured pelvis during the patient's transit to and from the operating theatre and thereafter has been discussed in connexion with rupture of the bladder on p. 626. Blood transfusion or infusion of a blood substitute throughout the operation is essential.

When the facilities for cysto-urethrography are lacking and there is any doubt about the diagnosis, instrumentation of the urethra should be undertaken in the operating

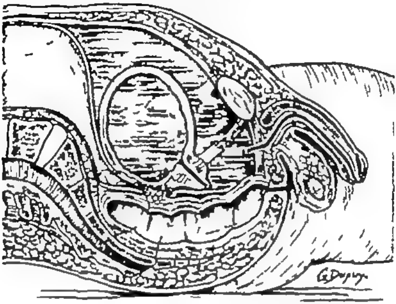


Fig. 912.—Intrapelvic rupture of the urethra. The puboprostatic ligaments are torn, and the bladder, which may be moderately distended, becomes displaced backwards. (Cf. Fig. 913.)

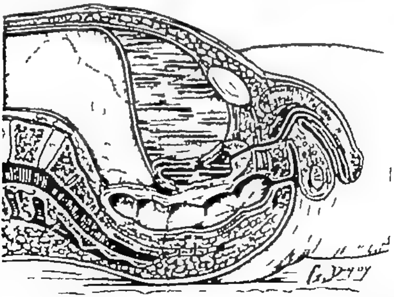


Fig. 913.—Extraperitoneal rupture of the bladder. The bladder is empty or practically so. (Cf. Fig. 912.)

theatre. The surgeon must be watchful lest the passage of a catheter into the prevesical space and the withdrawal of a few ounces of blood-stained urine from this situation, be mistaken for an entry into the bladder. This is a trap into which many have fallen.

The method of draping the towels, the site of the incision and the directions for inspecting the interior of the peritoneal cavity are exactly the same as those described on p. 620 for ruptured bladder. Blood and urine are aspirated or mopped from the prevesical space; even

then, amidst the blood stained effusion it may not be easy to determine the exact site of the lesion. The guiding rule is if the bladder is even moderately distended the lesion must be situated below the internal vesical sphincter. Thus the diagnosis of rupture of the urethra is confirmed (*Figs* 912, 913) When as is often the case hæmorrhage from the depths of the pelvis is profuse packing should be inserted while other matters receive consideration

Before opening the bladder the bony pelvis should be manipulated into the best possible position An assistant exerting traction on the lower extremities may facilitate this procedure

Occasionally elevation and internal fixation of the fragments of the pubic bones are necessary to avoid further trauma to the soft parts post-operatively

Fig 914.—Complete intrapelvic rupture of the urethra. The two Lister's sounds are manipulated until their beaks are indisputably in contact. The instrument on the left is then guided by it fellow into the bladder and the tear in the membranous urethra is bridged. A, Method of attaching the rubber tube to the beak of a Lister's sound

Suprapubic Cystostomy is performed Unlike extraperitoneal rupture of the bladder identification of the bladder in intrapelvic rupture of the urethra seldom presents any difficulty because of the urine it contains.

Methods of negotiating the Breach of Continuity of the Urethra.—

Method 1.—If the left index finger is passed through the internal urinary meatus into the prostatic urethra, not infrequently it is possible to guide the beak of a Lister's sound which has been passed down the anterior urethra, into the bladder The long rubber tube referred to already is milked on to the beak of the sound, which is slowly withdrawn from the external urinary meatus, and in this way the rubber tube is drawn past the rupture along the whole course of the urethra.

Method 2.—The larger Lister's sound is inserted into the internal urinary meatus and passed along the prostatic urethra to the seat of rupture. The smaller Lister's sound is passed through the external urinary meatus, along the urethra, until it comes into contact with the tip of the first. The two sounds, one in each hand, are manipulated gently until their beaks lie in contact with one another end to end (*Fig.* 914). By withdrawing the first bougie and advancing the second, keeping the beaks in contact, it is possible to guide the second bougie past the seat of the rupture and into the bladder: no force must be used. The first sound is removed; the second is made to protrude through the suprapubic opening. A rubber tube is attached to the beak, as described in Method 1, and by withdrawing the sound through the external urinary meatus, the tube is laid along the whole course of the urethra (Banks's method).

Method 3. Pass a Lister's sound through the internal urinary meatus, and make its beak emerge through the severed upper end of the urethra into the prevesical space. Thread one end of the rubber tube on to the tip of the sound, and withdraw the sound, thus carrying the tube into the bladder and out of the suprapubic wound. Clip the tube in a hæmostat, and disconnect the sound. Insert the same sound into the external urinary meatus, and make its beak appear in the prevesical space. Thread the other end of the tube on to its tip (*Fig.* 915), and withdraw the sound, thus bringing the tube along the whole course of the urethra. If there is difficulty in threading the tube on to the sound passed from below, tilting the patient into steep Trendelenburg's position facilitates this step.

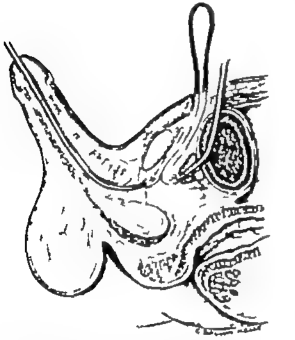


Fig. 915.—Method of negotiating the gap by threading each end of a rubber tube on to a Lister's sound.

The third method is only necessary when both the first and second methods prove unsuccessful.

Inserting a Foley's Catheter.—To the suprapubic end of the rubber tube attach a long piece of strong silk, by means of a needle and a knot. By pulling on the rubber tube from the external urinary meatus, the silk is made to traverse the whole course of the urethra. The silk is cut just above the knot, and the rubber tube is discarded. The Foley's catheter is taken, and a tight ligature is tied just beyond the eyes. In this instance the catheter is *to be regarded as a splint and should not be used for drainage*. The free end of the long piece of silk is threaded on to a needle which transfixes the Foley's catheter near its tip, enabling the silk to be tied to the catheter. By pulling on the end of the silk emerging from the suprapubic wound, the Foley's catheter is made to traverse the whole length of the urethra, and its balloon enters the bladder. After the bag has been moderately distended with water the side tube is folded on itself and ligated securely (*see Fig.* 918). The length of silk attached to the tip of the catheter is left protruding from the suprapubic wound to permit changing the catheter by the railroad method. It is convenient to wind the excess of silk around a stout piece of rubber tubing or a sterile wooden tongue spatula, and to secure it with a single knot.

The introduction of a Pilcher's bag is similar, but it is drawn into the urethra from above by attaching the silk to the proximal extremity of the tube.

In cases where the general condition is poor the operation can be concluded at this stage in the manner described below. However, the incidence of infection[1] is reduced, anatomical reposition is more perfect, and the complication of a burst bag is almost eliminated, by the addition of one more step before closing the wound.

[1] When a bag catheter alone is employed, infection is favoured (a) by possible pressure necrosis from prolonged weight extension on the catheter; (b) the necessarily comparatively long sojourn of an indwelling catheter when reliance is placed on the catheter alone.

Reposition of the Prostate in an Anatomically Correct Position by Sutures (L. A. Orkin).—Two long sutures of heavy silk are passed through the substance of the prostate on either side of the middle line, towards its apex with a fully curved needle on a holder. The curved needle having been removed, each of the four ends of these sutures is threaded on straight cutting needles (*Fig.* 916). An assistant removes the towel covering the scrotum, flexes and abducts the right knee, elevates the scrotum and sterilizes the skin of the perineum. With the vesical neck and the prostate under direct vision, the surgeon passes the sutures below the symphysis pubis to emerge in pairs lateral to the middle line of the perineum. The assistant catches each needle in a hæmostat as it appears, and pulls the suture through. While the surgeon holds the displaced prostate in the anatomically correct position, each of the two stay sutures is tied over a small rubber tube by the assistant. The knot is tied just tight enough to maintain perfectly correct anatomical alinement, and no tighter. The perineum is then covered by a dry dressing. This accomplished, the assistant extends the leg, and the sterile towels are replaced.

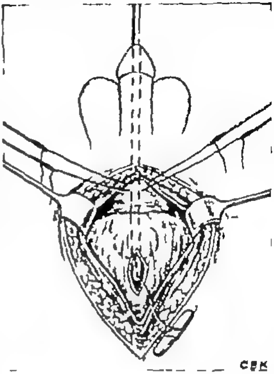


Fig. 916.—Traction sutures are placed in the prostate prior to passing each pair through the triangular ligament to the perineum, where they are tied. (*After L. A. Orkin.*)

Concluding the Operation.—The opening in the bladder is closed around a large drainage tube, which will be used for sump drainage (see p. 189). Two Penrose drains are inserted into the prevesical space, one on either side of the middle line (*Fig.* 917). The abdominal wall is closed in the usual manner and all tubes are anchored to the skin.

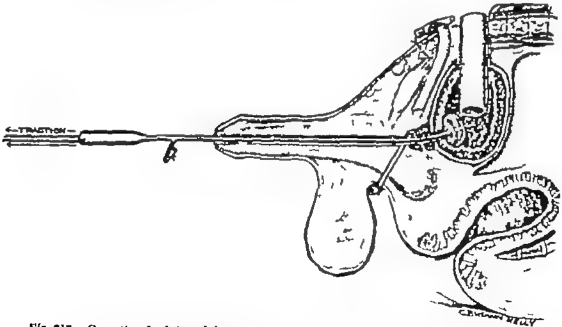


Fig. 917.—Operation for intrapelvic rupture of the urethra, including suture of the apex of the prostate to the perineum, completed. (*After L. A. Orkin.*)

Effecting Extension via the Catheter when Anchoring Sutures have been employed.—Much lighter extension is required than in the case of a sutureless operation. By the mediation of a silk suture passed with a needle through both lateral walls of the expanded

Drainage of the Infiltrated Area.—A long incision on each side of the median raphe of the scrotum. For reasons set out above these incisions should pass no deeper than beneath the superficial fascia. The incisions into the infiltrated area of the abdomen (*Fig.* 930) should be bowed and extend beyond the infiltrated area for a short way into the normal tissue. If this is not done infiltration often continues.

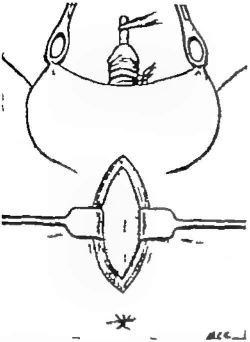


Fig. 928.—Peri-urethral abscess with extravasation. The perineal stage of the operation. *Note the method of maintaining* the bougie in position. A hæmostat prevents it going in too far whilst a turn of bandage tied behind the glans prevents its coming out. Lane's tissue forceps are acting as scrotal retractors.

Fig. 929.—A towel clip is used to pierce the catheter. To endeavour to pass a needle and thread through a gum-elastic catheter without this preliminary step entails a great deal of trouble.

At the conclusion of the operation the drip infusion of dextrose-saline is commenced cautiously. This is an important part of the treatment of the case, for as pointed out already, considerable depression of the renal function is part and parcel of that clinical entity—peri-urethral abscess with extravasation.

Fig. 930.—Patient convalescent from peri-urethral abscess with extravasation. A, B Incisions into the infiltrated tissues.

Fig. 931.—Sloughing of the overlying skin after extravasation of urine. Involved area treated by skin-grafting during convalescence. (*G. J. Carr.*)

Immediate After-treatment.—There is no doubt that anaerobic organisms are largely responsible for the spreading of cellulitis in these cases. Because streptomycin is contra-indicated in patients with poor renal function a broad-spectrum antibiotic is administered until a report on the sensitivity of the infecting organisms is to hand when, if necessary, substitutions can be made. Sulphonamide therapy should not be given until it is quite certain that the urinary output is adequate. As oxygen is inimical to gas-forming organisms, a good method is to place Carrel's tubes into the incisions and irrigate them with hydrogen peroxide followed by a weak antiseptic solution. Several observers have found peroxide of zinc most effective. The powder is sterilized and afterwards made into a cream with sterile water. It is applied liberally.

Local Complications.—

Residual abscess is frequently seen in the flank just above the anterior superior iliac spine. Under gas anæsthesia the abscess should be opened freely.

Sloughing of a large area of skin sometimes occurs (*Fig.* 931). Skin-grafts will probably be needed eventually.

More Remote After-treatment.—When the infection has subsided, which is usually in about 3–4 weeks, the treatment of the perineal fistula should receive attention.

Fig. 932.—Cock's operation. The finger in the rectum rests on the apex of the prostate and acts as a guide.

Fig. 933.—Teale's probe-pointed gorget.

Sometimes it is possible to dilate the stricture with bougies; at others, when the stricture is a tight one, internal urethrotomy with the insertion of an indwelling catheter is an effective method of dealing with the stricture and hastening closure of the wound.

The patient should not be discharged until the fistula has closed. Arrangements must be made for the stricture to be dilated regularly.

Cock's Operation is an external urethrotomy that opens the urethra behind the stricture and without a guide. It is indicated in those cases of peri-urethral abscess and extravasation in which a bougie cannot be passed. These cases are very few and far between.

Technique.—Lithotomy position. It is of the utmost importance that the body and the pelvis should be straight so that the median line may be accurately preserved. The left index finger is introduced into the rectum and the tip of the finger is lodged at the apex of the prostate (*Fig.* 932). The knife (Cock used a double-edged knife) is plunged steadily but boldly into the middle line of the perineum and carried on towards the tip of the left forefinger. The point of the knife enters the dilated urethra just in front of the apex of the prostate. When it is certain that the knife has penetrated the urethra, the instrument is withdrawn, but the left forefinger remains in position, and, guided by the Teale's probe-pointed gorget (*Fig.* 933) is passed into the wound, and, guided by the

left forefinger enters the urethra and is passed onwards into the bladder A large coudé *catheter is slid along the director which is then removed*, and the catheter having been cut short, is secured to one side of the wound with a stitch

The after treatment is as detailed above.

FOREIGN BODIES IN THE URETHRA

In the male, foreign bodies are usually introduced into the urethra with the object of relieving acute retention. More often than not the foreign body fails to give the desired relief, and we have to perform the dual service of retrieving the object and relieving the retention. In locating the foreign body a radiograph is often valuable (*Fig* 934). *Urethroscopy should be performed* whenever possible By this means the foreign body if in the anterior urethra, can be seen. Many if not most, foreign bodies can be extracted in the following way The sheath of the urethroscope is left in situ, and a pair of alligator forceps seizes the foreign body (*Figs.* 935 936). The sheath the forceps, and the foreign body are then removed *en bloc* (*Fig* 937).

Fig 934—Hairpin in bulbous and membranous urethra inserted by a patient to relieve acute retention Removed in a urethroscope sheath.

B. G., aged 46, had been drinking heavily one Saturday night, and on getting home found *that he was unable to pass urine. Towards* morning the pain became intolerable, so, having armed himself with a hairpin, he went downstairs and proceeded to attempt to get relief. A few hours later he was admitted to hospital with the bladder extending almost to the umbilicus and the hairpin lost within the depths of the urethra. Morphine, gr ¼ (0·016 G), and a hot bath relieved the retention. After urethroscopy the hairpin was caught with alligator forceps through the sheath of the urethroscope. The forceps, sheath, and hairpin were then extracted together

Fig. 935.—Foreign body in urethra. Urethral forceps are introduced through the sheath of a urethroscope

Irregular foreign bodies, or those of long standing which have become encrusted with phosphates, are best dealt with by opening the inferior wall of the urethra at the site of the obstruction. After the extraction has been effected, the concomitant infection renders it necessary to leave the lips of the wound open widely

In the absence of a urethroscope pins and needles in the anterior urethra may be extracted by angulating the penis in such a way as to make the sharp point of the foreign body protrude through *the floor of the urethra* ... *case of a needle once the* point

has protruded it may be extracted immediately; but a pin, on account of its head, must be manipulated so that the head points towards the meatus (*Fig.* 938).

Fig. 936.—Alligator forceps.

Fig. 937.—Sheath of the urethroscope forceps, and foreign body (a hairpin) removed *en bloc*.

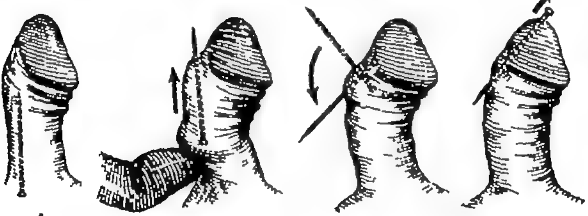


Fig. 938.—Method of removing a pin from the urethra. (*After Meredith Campbell.*)

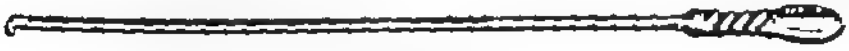


Fig. 939.—Wheelhouse's staff.

External Urethrotomy.—The indications for external urethrotomy as such will be confined to the removal of foreign bodies and urethral calculi when other methods have failed. As the other methods which have been detailed are almost always successful, the indications for external urethrotomy are necessarily limited.

Technique.—Lithotomy position. Wheelhouse's staff (*Fig.* 939) is passed to the point of obstruction and then rotated, so that the groove lies towards the floor of the urethra. Cutting on to the groove the urethra is opened and the obstructing agent is removed.

Wheelhouse's operation is now seldom employed for the relief of acute retention of urine due to an impassable urethral stricture. These now infrequent cases are better treated by suprapubic catheterization followed at a later date, when the function of the kidneys has been shown to be satisfactory, by internal urethrotomy.

CONTROL OF HÆMORRHAGE FROM THE URETHRA

Severe Hæmorrhage from a Urethral Chancre.—In the solitary example of this condition that has come under my notice a catheter was passed and the penis firmly bandaged. The method proved effective.

Hæmorrhage after Internal Urethrotomy.—Although this operation is not now performed frequently, the results are usually most satisfactory. Being a blind operation, post-operative hæmorrhage is its chief danger.

I have lost two patients from this complication, and I feel that both could have been saved if I had understood the complication better. In the first case the hæmorrhage started on the day after operation. It was checked by tying in a catheter. Evidently some of the blood had passed backwards into the bladder, for clots were evacuated when the bladder was washed out. For some days dark, blood-stained urine was passed, but on every occasion the wash-out was soon returned clear. Infection supervened, and the patient died of pyelonephritis. Here was a mistake. Suprapubic cystostomy or perineal urethrostomy should have been performed as soon as the bleeding was recognized. Not only would this measure have prevented urine passing over the lacerated tissues, but, what is even more important, all the blood-clot could have been evacuated from the bladder instead of allowing some of it to remain and putrefy, which undoubtedly was the cause of death.

The second patient had a large hæmorrhage on the tenth day. It was checked by tying in a catheter. As he had a suprapubic cystostomy I thought all was well. Four days later a second hæmorrhage occurred. After a blood transfusion perineal section was performed and a fair-sized calculus was discovered in the dilated urethra behind the stricture. There was some ulceration around the area which harboured the stone, and it was concluded that this was the bleeding point. The wound was packed. One week later he had a further severe hæmorrhage; again transfusion and packing were employed. These events were repeated. Eventually he went downhill in spite of transfusion.

As a result of this experience I think late hæmorrhage after internal urethrotomy should be treated by (1) diversion of the flow of urine, and (2) extending a perineal section right through the stricture or strictures and packing the interior with gauze moistened with snake venom or thrombin topical. Blood transfusion will, of course, be given as required.

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CHAPTER LIX

THE PENIS

Meatotomy.—This is a satisfactory little operation and is not practised frequently enough. Pin hole meatus and atresia meati are the indications *par excellence* for this measure but there are many cases in which the meatus is small enough to prevent the introduction of a catheter of satisfactory calibre or a urethroscope. A urethral calculus sometimes can be extracted after the meatus has been enlarged.

Technique.—The frenum and the glans immediately beneath the meatus are infiltrated with 1 per cent procaine (*Fig.* 940 A). A narrow bladed scalpel is passed into the meatus, with its cutting edge downwards, and with one sharp cut the meatus is enlarged, preferably a little to one side of the middle line the better to avoid the frenal artery (*Fig.* 940 B). Sutures are unnecessary. Unless a sound of suitable calibre is passed into the meatus daily for about a week the atresia is liable to recur. For at least four weeks following this the patient should attend for dilatation.

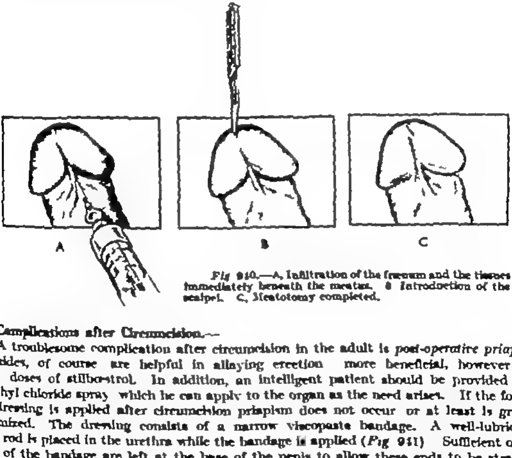

Fig. 940.—A, Infiltration of the frenum and the tissues immediately beneath the meatus. B, Introduction of the scalpel. C, Meatotomy completed.

Complications after Circumcision.—

A troublesome complication after circumcision in the adult is *post-operative priapism.* Bromides, of course, are helpful in allaying erection; more beneficial, however, are 5-mg. doses of stilbœstrol. In addition, an intelligent patient should be provided with an ethyl chloride spray which he can apply to the organ as the need arises. If the following dressing is applied after circumcision priapism does not occur, or at least is greatly minimized. The dressing consists of a narrow viscopaste bandage. A well-lubricated glass rod is placed in the urethra while the bandage is applied (*Fig.* 941). Sufficient of the ends of the bandage are left at the base of the penis to allow these ends to be strapped by adhesive plaster to the pubis. This will ensure that the bandage does not slip. The entire penis being bound up, the glass rod is removed. At the end of ten days the dressing is slit up with scissors and discarded.

Hæmorrhage after circumcision usually occurs from the region of the frenum. The three-in-one frenal stitch minimizes this untoward occurrence (*Fig.* 942). Further, it can be used to stop post-operative bleeding in this area. When bleeding is coming from any part of the cut surface an interrupted stitch or two will usually control the hæmorrhage, especially when ribbon gauze soaked in tinct. benzoin. co. is wrapped around the region

of the corona. When persistent bleeding occurs after circumcision, hæmophilia should be suspected, and measures taken forthwith to supply the deficient factor (see p. 68).

Retraction of the skin covering the penis, leaving the shaft bare is not unknown, particularly after the operation where no sutures are used. The condition is remedied by placing appropriate stitches after cleansing carefully the exposed area.

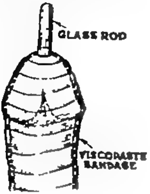

Fig 941.—Technique of the dressing.

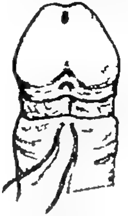

Fig 942.—The three-in-one frenal stitch.

Local Anæsthesia of the Penis.—Although it sounds dangerous, ideal anæsthesia of the whole of the penis can be obtained by injecting 2 per cent procaine into the base of each corpus cavernosum (*Fig* 943). Using a No 23 gauge needle 10 ml. (170 min.) is injected. A cardinal injunction is that the needle having been introduced into the corpus, if blood is aspirated, the injection must not be made at that point. It is unusual for blood to be aspirated. On occasions this form of anæsthesia is useful in cases of irreducible paraphimosis.

Fig 943.—Cross-section of the penis, showing sites of injection with local anæsthetic (*After Magid and Culp*)

Fig 944.—A method of reducing a paraphimosis.

Paraphimosis.—

Treatment with Hyaluronidase In early cases, i.e., under 6 hours duration, 150 T.R units dissolved in 1 ml of normal saline solution is injected and dispersed into the œdematous ring at 3 and 9 o'clock positions. In about 2 minutes the œdema takes on a pitting quality at the end of 12 minutes the swelling of both the ring and the frenum has disappeared. The prepuce can be restored to its original position by manipulation (*Fig* 944). To avoid repetition, circumcision should be performed later

Irreducible Paraphimosis—In my experience the classical operation, which consists of nicking the constricting band in several places and forcible reduction with the thumbs—

usually performed under a general anæsthetic—is not effective after about 24 hours. Moreover forcible reduction, if not immediately successful causes much bruising furthermore, after the nicking and battering the penis has received it is not unusual for infection to supervene

For these reasons the surgeon is advised to proceed as follows: under local anæsthesia the constricting band is incised (*Fig* 945) and then the narrow cuff of skin which forms that band is excised (*Fig* 946) This leaves an œdematous collar attached to the corona. When the œdema has been reduced by circular compression with a constricting length of gauze the collar will be seen to consist of the mucous membrane just behind the corona. On the other side of the gap left by the excision of the band is skin, a further cuff of which is excised according to judgment, before uniting skin to mucous membrane as in circumcision.

Fig 945.—Paraphimosis. Nicking the constricting band

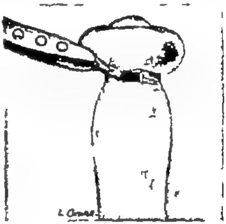

Fig 946.—Paraphimosis. Excising the constricting band.

Fracture of the Penis.—Fracture of the erect penis is a rare but definite accident. In cases in which it has been noted there are usually evidences of old-standing peri urethral fibrosis. Some patients have alleged that they heard a snap at the time of the accident. In Central Africa the condition is well known, for women have learned that an effective method of preventing rape is to take a firm hold of the penis and sharply bend it backwards towards the anus. (J Smibert.) The organ suddenly becomes flaccid, and excruciating pain is followed by great swelling from the extravasated blood.

The condition should be treated by immediate operation. Through a suitable incision clots are turned out and the corpora cavernosa repaired with sutures When the corpus spongiosum is the seat of the rupture, in addition to repairing this structure, the torn urethra must be united carefully

De la Cour and Stephens recorded a case of rupture of the corpus cavernosum that occurred during coitus. The subcutaneous tissue of the penis and the whole of the scrotum were discoloured with extravasated blood. At operation the tunica albuginea of the left corpus cavernosum was found torn. After removing blood-clot, the fascia of the penis was united and the wound closed. Unimpaired function of the organ resulted. In W Halloran s case it was the corpus spongiosum which was torn. A man aged 56 noticed sudden pain during coitus. Soon afterwards the penis became swollen cold and œdematous distal to an angulation. There were subcutaneous hæmorrhages, and bleeding occurred from the meatus. Halloran made an incision and after removing blood-clot repaired the torn urethra and corpus spongiosum with sutures.

Strangulation of the Penis by Rings.—After a ring has been placed upon the penis, venous engorgement follows and strangulation ensues. In early cases aspiration of the corpora cavernosa with a needle and syringe may assist removal by lessening vascular engorgement. When the ring has been on for some time and is firmly embedded, the aid of a locksmith must be sought.

V Vermooten describes a case where the offending ring was of thick cast iron and could only be dealt with by an electrically driven circular saw The saw was applied at two diametrically opposite points on one side the ring was cut half way through on

the other the machine was stopped when it had almost traversed the whole thickness of the iron. The ring was finally severed with a cold chisel and a hammer Gullot, confronted by a baker with a gold wedding ring firmly impacted upon the penis, used the ingenious method of dissolving the gold in a mercury bath

Simple homely methods are sometimes useful. When newly appointed as a casualty officer I was confronted by an excited individual who demanded that a friend in a cab outside should see the doctor alone Draped in a long cloak, the friend was duly led behind the examining screen. The cloak having been removed the cause of the excitement was evident, for the patient's penis was impacted in a stone hot water bottle that he supported with his hands. A wet towel having been placed over the receptacle release was effected by the blow of a hammer

Avulsion of the Skin of the Penis and/or the Scrotum.—Traumatic avulsion of the skin of the penis and the scrotum is encountered with increasing frequency Entanglement of clothing in rotating machinery accounts for the majority of these injuries. A varying amount of the skin of the penis is avulsed but in most cases the shaft of the penis is uninjured. Partial or complete avulsion of the scrotum may occur in addition, or alone usually the partially or completely denuded testes are remarkably free from damage

When any part of the skin remains attached, or even if the completely detached skin is available it is worth while replacing the skin of the penis, for it frequently survives. On the other hand detached scrotal skin should not be replaced as such a step is almost doomed to failure because it is impossible to maintain sufficient pressure on the area. Replacement of penile skin is carried out as soon as treatment for shock has been commenced. All other procedures must be postponed until the patient has recovered from shock . The first steps of the operation are débridement of non-viable tags and hæmostasis.

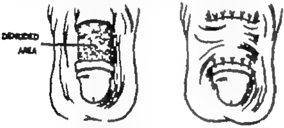

Fig 947 —Covering the denuded shaft of the penis by burying it in a scrotal tunnel. (*After Goodwin and Thelen*)

Covering the Denuded Penis.—

a. The most satisfactory method for one not particularly familiar with skin grafting is to bury the shaft of the penis in the scrotum (*Fig* 947) with subsequent surgical release at a propitious time

b. If a dermatome is available a split thickness graft large enough to cover the penile shaft completely and allow for contraction is cut from a relatively hairless area. The cuff of foreskin which is often left intact is removed, and only a small rim of mucosa about the corona is preserved. The graft having been applied, a dressing that will maintain even pressure is mechanic's waste over which is bound a viscopaste bandage Skin-grafting is obligatory when the scrotum has also been torn away

Covering the Testes.—Sometimes the remnants of the scrotum are sufficient to allow a scrotal bag to be fashioned particularly if undercutting of the junction of the scrotum with the skin of the thighs is performed. If this measure is not feasible or inadvisable because of the patient's poor general condition, oblique incisions are made in the thighs to accommodate each testis and its spermatic cord or better if time permits, is to undermine the skin of the upper thigh adjacent to the perineum on both sides, and to swing the testes laterally to a subcutaneous position for temporary housing Plastic procedures, to construct a new scrotum can be considered later remembering that a scrotum constructed of non-scrotal skin cannot function as a thermo-regulating mechanism.

Wounds of the Penis.—Unless the blood-supply to the penis is manifestly inadequate—a rare event—amputation should rarely if ever be performed in the first instance When the urethra is involved which is usual suprapubic cystostomy is necessary In an early case after débridement of the wound, the skin should be sutured or in the case of an infected wound, petroleum-jelly gauze is used to pack lightly the defect. The organ should then be bandaged, and splinted in an upright position. There is nothing lost by conservatism ; the wound usually heals readily Often a badly mutilated organ as well as the urethra can be reconstituted later by plastic surgery

Acute Balanitis is, more correctly speaking an acute balano-posthitis, for there is inflammation of the opposing surfaces of the glans penis and prepuce. The occasional

presence of glycosuria makes it imperative to test the urine for sugar in every case. Three varieties are recognized, all of which are favoured by phimosis:—

Purulent: When the prepuce cannot be retracted, and particularly if it has been torn at coitus, a chronic balano-posthitis is liable to become acute and painful. The prepuce is red and swollen, and pus exudes from beneath it. Bacteriological examination of the pus is essential, and it usually reveals a highly mixed infection, much less frequently a pure culture of one organism. Cases of diphtheria of the glans have been reported. Even with bacteriological assistance it is impossible to exclude a Hunterian chancre or urethritis behind a prepuce that cannot be retracted.

Erosive (syn. fourth disease) is due to Vincent's organisms (spirilla and fusiform bacilli) probably transmitted by infected saliva. The surface of the glans and post-coronal sulcus, together with the under surface of the prepuce, become eroded in small areas that appear white. In the more severe lesions these erosions are succeeded by ulcers with reddened borders and a yellowish white base, in which event constitutional symptoms will be evident.

Gangrenous (syn. phagedæna). In virulent forms of the above and in cases secondary to chancroid, where free drainage is not provided, occasionally the prepuce becomes black and gangrenous, and the patient becomes acutely ill with general malaise and a high fever. Acute retention of urine sometimes complicates the situation. Gangrene of the skin of the penis, especially the under surface of the base of the shaft, is liable to complicate Fournier's gangrene (see p. 690), while a black patch on the penile skin is seen occasionally in superficial extravasation of urine, especially that complicating peri-urethral abscess (see p. 674).

Treatment.—Early treatment consists in giving systemic antibiotic therapy, and while awaiting the bacteriological report penicillin, together with an antibiotic with a wide range of activity, cannot be bettered. The preputial sac should be irrigated freely with saline solution, delivered with a Higginson's syringe to which is attached a Eustachian catheter instead of the usual nozzle. This is followed by an instillation of penicillin solution. Sometimes this treatment is followed by such improvement that resolution can be anticipated. Circumcision should follow in due course. Should conservative measures not improve matters within 24 hours, no time should be lost in excising a broad V from the dorsum of the prepuce under general anæsthesia. H. B. Taylor, after an immense experience of infected phimosis in China, is emphatic that immediate circumcision (under antibiotic cover) gives better and quicker results than a dorsal slit.

When gangrene has supervened the whole of the prepuce and gangrenous skin covering the penis should be removed with a diathermy knife. Eventually a healthy granulating surface presents, and this can be covered by a skin-graft (see p. 677). If the glans sloughs, severe secondary hæmorrhage is probable, and to avoid this, partial amputation of the penis in cases where the base is comparatively healthy, or removal of the sloughing area with a cautery, becomes necessary. Finally, remember the likelihood of urethral stenosis following the suppuration, and prevent this by passing bougies regularly.

Penile Peri-urethral Abscess.—The abscess arises in an infected follicle of Littré, as a complication of acute (rarely chronic) urethritis. A tender induration can be felt on the under surface of the penis. Left to nature, the abscess frequently bursts externally, and a urinary fistula may result. Early incision per urethram, supplemented by penicillin, is the best method of abruptly terminating these untoward possibilities. The help of an aero-urethroscope is desirable, but if the abscess is near the meatus, as it usually is, it may be dealt with by inserting a tenotome down the urethra.

Persistent Painful Priapism.—Many cases of persistent painful priapism are due to thrombosis of the deep pelvic veins. Priapism is a recognized complication of leukæmia—particularly of myeloid leukæmia; at the preliminary examination do not forget to examine the spleen for enlargement. It also occurs as a complication of sickle-celled anæmia, which occurs only in those of negro race, or their descendants. Whether the cause of the priapism is neurological or vascular, if erection has persisted for two days thrombosis exists in the corpora cavernosa, and this thrombosis is sufficient to sustain the erection. In such cases the use of sedatives, narcotics, cooling lotions, and rectal diathermy are absolutely useless; curare-like drugs and diethylstilbœstrol may be helpful in the early stages. If a low spinal anæsthetic is given, and the priapism persists, it proves that the condition is due to intravascular clotting.

Aspiration should be undertaken. Very occasionally it is permanently successful. A point on the skin of the penis about midway down the organ is anaesthetized and the underlying fascia is injected with local anaesthetic also. An aspirating needle of large size fitted to a syringe is plunged into the corpus cavernosum (*Fig.* 948). On withdrawing the piston, dark blood is evacuated. The needle is passed more deeply and the corpus cavernosum of the opposite side is aspirated. When aspiration has been effected, flaccidity occurs. A 10 per cent solution of heparin in normal saline is then injected, and the priapism reappears. Aspiration and injection are repeated several times, in order to wash out the spongy meshwork, and the organ is left in a flaccid condition.

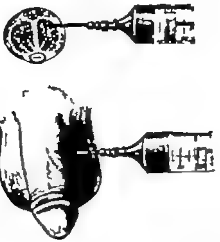

Fig. 948.—Deflating the corpora cavernosa by aspiration.

Systemic anticoagulant therapy (see p. 927) can also be tried but if this does not register some success in 48 hours, it should be abandoned in favour of operation, allowing sufficient time for the particular anticoagulant employed to be wholly or partially neutralized by its specific antidote.

Ligation of the dorsal arteries in addition to evacuating blood and clots by incising the corpora cavernosa has been advocated. I carried out this measure in one case; gangrene of the penis (*Fig.* 949) set in and amputation of the penis had to be performed (*Fig.* 950). The patient has remained in good health for many years.

Fig. 949.—Commencing gangrene following incision of a corpus cavernosum with suture combined with ligation of the dorsal arteries.

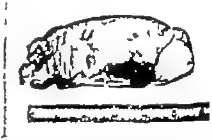

Fig. 950.—The penis amputated, showing gangrene. A prepubic cystostomy was performed because of persistent retention of urine.

Lowsley's operation appears to be the best that has been described. Under antibiotic cover and after having cleansed the operative area thoroughly the corpora cavernosa are exposed through a perineal incision. Each corpus cavernosum is incised freeing black blood and clots. Two catheters (Nos. 10 and 14) are passed into each corpus cavernosum, a pathway having been made for them with sinus forceps. The smaller catheter is for irrigation and the larger to evacuate dissolved clot. Constant bilateral drip irrigation with a solution of 1,000 ml. of saline solution, 100 mg. of heparin, and 200,000 units of crystalline penicillin is continued for six days. The catheters are then removed.

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CHAPTER LX

THE TESTES AND SCROTUM

TORSION OF THE TESTIS

TORSION of the testis, called perhaps more accurately torsion of the spermatic cord, is said to occur relatively frequently in an imperfectly descended testis. It has been my experience that it is the fully descended testis which is somewhat more often affected. The factors that favour torsion are illustrated in *Fig* 951 and it is clear that torsion occurs seldom, if ever, in a normal testis. Torsion of the *body* of the testis can occur, the twisting taking place between the body of the testis and the epididymis (Underhill). If complete torsion persists for 3–4 hours, infarction is inevitable, consequently it is but rarely that detorsion results in salvage of the testis. Patients with recurrent torsion sometimes learn successfully to perform detorsion upon themselves, but as a rule gradual atrophy of the testis ensues.

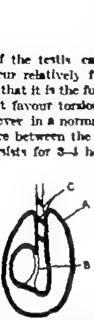

Fig 951.—Diagrammatic representation of the predisposing causes of torsion of the spermatic cord. A, Complete and high investment of the testis, epididymis, and cord by the tunica vaginalis. B, Testis and its adnexa hang in the vaginal cavity like the clapper of a bell; C, The cremaster muscle, which is attached spirally, will readily cause rotation of the clapper when the muscle contracts vigorously. (*After M. Muschat.*)

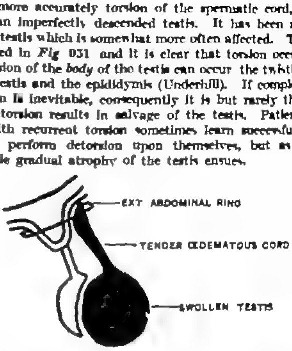

Fig 952.—Explanation of how a small strangulated hernia may cause testicular symptoms by pressure on the cord.

Torsion of the Fully Descended Testis.—The scrotal contents on the affected side are retracted upwards by torsion of the cord itself and by cremasteric spasm. Elevation of the scrotum intensifies the pain (Prehn's sign), whereas in epididymo-orchitis such elevation brings relief; however, this sign is not infallible.

Torsion of the testis can be a dangerous diagnosis if it conveys the (erroneous) suggestion of a condition that does not require immediate operation. A case that I have in mind was diagnosed as torsion of the testis on account of the engorged, tender cord, the swollen testis, and the small secondary hydrocele, but when operation was performed some six hours later a gangrenous Richter's hernia was found in the inguinal canal. This had pressed upon the cord at the external abdominal ring and accounted for the testicular symptoms (*Fig.* 952).

Sometimes when the patient is not seen until six or more hours have elapsed and gangrene of the testis has set in, an erroneous diagnosis of acute epididymo-orchitis is apt to be made, for the scrotum becomes slightly inflamed and the temperature registers about 99° F. *Fig.* 953 illustrates a case in point. If the patient presenting these symptoms is a boy, and recent mumps is excluded, it is far more likely that the symptoms are due to torsion of the testis or one of its appendages (*see below*), for acute epididymo-orchitis at this time of life is, apart from mumps, exceedingly rare. The frequency with which epididymo-orchitis is mistaken for torsion of the testis is revealed by the fact that each and all of seven consecutive cases of torsion of a fully descended testis that I was called upon to see had been diagnosed and treated as acute epididymo-orchitis for periods varying from 24 hours to 10 days.

When the diagnosis of torsion is tolerably certain and the patient is seen within an hour of the onset of the attack, manipulation can be attempted.

R. E. Smith's Case.—A schoolboy at Rugby was awakened at 3.30 a.m. with excruciating pain referred to a point one third along a line joining the anterior superior iliac spine to the umbilicus. At 6.45 a.m. he was writhing in agony. The right testicle was the size of a hen's egg and moderately tender. On rotating his testicle 180° from his left to right he volunteered the statement "That's better," but it required a further 180° before complete relief was obtained. He was left to hold the testicle in position for an hour. Three hours later the testicle was normal in size.

R. Burkitt advises that the testis be rocked gently to see which way the torsion has occurred, before rotation is attempted.

Even in early cases when untwisting is unquestionably successful operation within 24 hours should be advised in order to fix the testis and prevent a further attack.

In later cases, or when manipulation is not quickly and entirely satisfactory, the testis should be exposed through an inguinal incision with as little delay as possible. The skin should be prepared with aqueous metaphen or some other non-spirit-containing antiseptic, e.g. cetavlon; spirit causes unnecessary stinging pain and irritates the skin of the scrotum. The operation can be conducted readily under a local anæsthetic, especially if a preliminary dose of morphine has been given, or a general anæsthetic can be employed. The testis is delivered through the wound. If on untwisting the cord there are any signs of a return of the circulation, an attempt should be made to preserve the organ and to fix it by sutures in an anatomically correct position (*see below*). Experience teaches us that in the majority of instances when untwisting has been performed after the sixth hour atrophy of the testis ensues, although it takes several months to become manifest. Therefore if the testis appears blue-black and lifeless, the best course is to ligate the cord securely and remove the useless organ.

Fig 934.—Torsion of the testis. The inflamed, acutely tender right testis and scrotum simulate acute epididymo-orchitis exactly.

B. G., aged 15, had orchidectomy performed for torsion of the right testicle fifteen hours after the onset of symptoms. On the fourteenth day after the operation, whilst defecating he was seized with severe pain in the left testicle. Operation was carried out within four hours. The testicle was untwisted and found to be viable and it was fixed in the manner shown in *Figs* 935, 936. Seen three years later the patient's remaining testicle appeared normal, secondary sexual characteristics had developed and he had been passed as medically fit for service in the Royal Air Force.

Torsion of the Testis in the Newborn.—If direct trauma during delivery can be excluded, a hard swelling of one testis discovered at birth, or soon afterwards, is almost certainly due to torsion. Sometimes the blue discoloration of the testis can be perceived through the infant's thin scrotal skin.

The neonate is no exception to the rule that operation should be undertaken as soon as arrangements can be made.

Torsion of the Imperfectly Descended Testis.—It is often difficult if not impossible to distinguish this condition from a strangulated inguinal hernia. True, the corresponding side of the scrotum is empty and the possibility of the testis as a cause of the painful tender lump in the inguinal region springs to our minds. Notwithstanding, the lump in question often turns out to be a strangulated hernia, for is not a hernia a fairly regular accompaniment of a maldescended testis? There should be no hesitation in exploring the swelling promptly.

B. A., aged 14, for some years had a lump in his right groin. For three days it had been larger and painful, and he had vomited two or three times. On examination there

was a large irreducible right inguinal hernia. The testicle on the left side was absent, and the patient had hypospadias. The hernial sac was opened and was found to contain a testis black in colour. The cord was twisted three times. This was untwisted, but there appeared to be no life in the testis. Orchiectomy (*Fig.* 934). Herniotomy. Recovery.

Fig. 934.—Torsion of an imperfectly descended testis removed in the case of D. V. quoted in the text.

EMERGENCY OPERATIONS FOR TORSION OF THE TESTIS

Either an incision the same as that used for inguinal herniotomy or a vertical incision traversing the upper two-thirds of the scrotum can be employed.

Untwisting and Anchoring the Testis.—When untwisting of a viable organ has been possible the testicle should be fixed by sutures in the manner shown in *Figs.* 935, 936 in order to prevent recurrence. It may be argued logically that if the anatomical anomaly which allows a testicle to twist is present on one side the same condition is likely to be found on the contralateral side. Wherefore in every case of torsion of the testis and especially if a patient has lost a testicle through torsion, exploration of the contralateral side and, if the 'clapper of a bell' abnormality is found, fixation is advised; this can be undertaken at some convenient time after reasonable convalescence but it should not be long delayed.

Orchiectomy as an emergency measure should be performed rarely—so often the testis can be saved. The principal indication for urgent removal of the testicle is torsion when untwisting cannot be effected satisfactorily or when gangrene has set in.

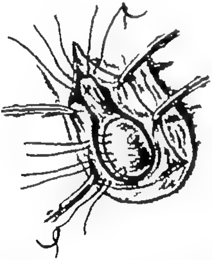

Fig. 935

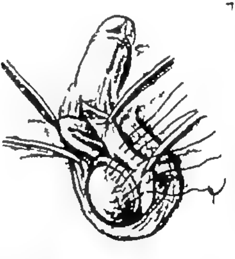

Fig. 936

Figs. 935, 936.—Mode of anchoring the testis with sutures to prevent recurrence of torsion. The left hand figure shows lateral mattress sutures, the right hand medial mattress sutures to the septum dartos. The sutures are passed in each case through the tunica albuginea. Fine silk or thread is perhaps the best material to employ in order to make the anchorage permanent.

Technique.—The testis having been delivered, the cord is isolated and crushed at a point conveniently distant from the external inguinal ring. The cord is then transfixed and ligated. To err on the side of safety it is a good practice to employ two ligatures, one applied a quarter of an inch distant from the other. When the ligatures are securely in place the cord is severed and the testicle removed.

Post-operative Slipped Ligature.—The spermatic cord is a very vascular structure which retracts readily. Insecure ligation of it can prove a most unpleasant complication. M. F. Campbell reported a case where fifteen minutes after an operation for varicocele the patient's dressings were found soaked in blood. The wound was re-opened promptly but the bleeding stump had retracted so far that it was necessary to incise the muscles of the lateral abdominal wall and retract them widely before the proximal venous stump could be retrieved.

TORSION OF AN APPENDAGE OF THE TESTIS

Vestigial structures related to the testis and epididymis—namely the hydatids of Morgagni, the paradidymis or organ of Giraldés, and the vasa aberrantia—are liable to undergo axial rotation. The commonest of these structures to twist is the pedunculated hydatid (Fig. 937). Torsion of an appendage of the testis is essentially a lesion occurring before or at puberty. No doubt many cases have escaped recognition and have been looked upon as examples of epididymo-orchitis of unknown origin. Apart from the orchitis of mumps, acute epididymo-orchitis is of the utmost rarity in young boys, whereas torsion of the appendages of the testis cannot be exceedingly unusual, for I operated upon 14 cases of this condition in 10 years. Therefore, if a boy gives a history that one side of the scrotum has become swollen following a sudden attack of pain, torsion of an appendage of the testis should at once spring to mind as the diagnosis. Treated expectantly the affection runs a rather painful course accompanied often by pyrexia, but resolution occurs eventually in all cases. Immediate operation with ligation of the pedicle and amputation of the twisted appendage terminates the symptoms abruptly.

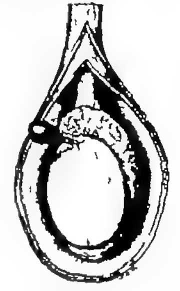

Fig. 937.—Torsion of the pedunculated hydatid of Morgagni. (*After Fosker.*)

RUPTURE OF THE TESTIS

Even when the damage is severe, repair is possible, as is well shown by the following case:—

A. G., aged 23, whilst playing football was kicked in the scrotum. He continued to play for a short while. Six hours later a large scrotal hæmatoma had developed. The testis was exposed, and after blood and blood-clot had been swabbed away the body of the testis was found to be split cleanly as if cut with a knife. The testis was repaired with catgut sutures, the wound closed and a firm scrotal bandage applied. Recovery was uneventful, and when the patient was seen six months later palpation of the testicle revealed an organ indistinguishable from normal.

Fourteen similar cases have been reported. In only three instances did the accident produce severe shock.

Avulsion of the Scrotum.—(*See* AVULSION OF THE SKIN OF THE PENIS AND SCROTUM, p. 684.)

RECENT HÆMATOCELE

Recent hæmatocele is usually the result of injury of a small vessel during tapping or aspiration of a hydrocele. Prompt refilling of the sac with considerable pain and tenderness, and poor or absent transillumination, leaves no doubt as to the diagnosis. The treatment should be urgent operation, with evacuation of blood, followed by hydrocelectomy. If this course is not followed, after a prolonged period of rest accompanied in the early stages by pain, an old clotted hæmatocele will almost certainly result.

Acute hæmorrhage into a previously normal tunica vaginalis can result from a blow on the testis. The treatment should be similar to the above for the reasons given, and also because without exploration it is impossible to tell whether or not the testicle is ruptured.

In cases such as these the testis can be exposed through a long vertical scrotal incision under local anæsthesia, and can be delivered without pain if the cord is infiltrated with 1 per cent procaine just outside the *external inguinal ring*. Great attention is paid to hæmostasis, for if the slightest oozing occurs a scrotal hæmatoma develops; for this reason, the insertion of a drainage tube in a dependent portion of the scrotum is most necessary. The tube can be removed after 24 hours.

Whether drainage is considered necessary or not, after all operations upon the testis, scrotum, and inguinal canal, in order to minimize dead space it is a good practice to support the scrotum by Nitschke's scrotal bandage (*Fig.* 938). A square of surgical gauze measuring 18 in. × 18 in., is folded diagonally. A small roll of gauze about 3 in. long and ½ in. thick, is placed in the centre between the layers of the preceding fold. Just above the roll a small hole is made with a pair of blunt-ended scissors. A piece of 2½ in. bandage 10 in. long is folded in the middle; the folded end is pushed through the opening made in the gauze and looped through. Another piece of bandage is tied round the patient's waist and the scrotal bandage is applied firmly so as to elevate the scrotum. The ends are fixed as shown in the figure. Then two ends of the gauze are tied to the waist-band after which a hole is made in the gauze to accommodate the penis. This easily made scrotal support will be found extremely useful.

Post-operative Scrotal Haematoma. — *Hyaluronidase Treatment.*—In early cases, when the blood can be presumed to be unclotted, after cleansing the scrotum, aspiration can be attempted. Whether or not this is successful a solution composed of 300 T.R. units of hyaluronidase dissolved in 30 ml. of saline solution with 5 ml. of 1 per cent procaine and 300 000 units of aqueous crystalline penicillin can be injected into the scrotum, after which pressure is applied to the scrotum by means of a tight Nitschke's bandage. In a number of cases, within 24 hours the scrotal distension has diminished greatly.

Drainage.—On the other hand, when the haematoma is a large one and probably of more than 24 hours' standing

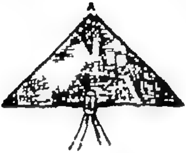

Fig. 938.—Nitschke's scrotal bandage.

after local anaesthetic has been injected into a dependent part of the scrotum a small incision is made with a narrow bladed scalpel. Clots are expressed; one stitch is sufficient to close the skin incision. A dry dressing is applied, and the scrotum is elevated and compressed by a scrotal bandage. Systemic antibiotic therapy is given.

This course obviates the long wait necessary for absorption of blood-clot to take place and the risk of infection is greatly diminished.

ACUTE EPIDIDYMO-ORCHITIS

Although clinically the inflammation sometimes appears to be confined to the epididymis or less frequently to the body of the testis, usually in acute cases both these structures are involved. In a high percentage of cases the infection is secondary to infection of the corresponding seminal vesicle which in turn is infected from the prostatic urethra. Probably such infection travels along the lumen of the vas, although it is possible that it occurs via the lymphatics that accompany the vas. Infections can be blood-borne, examples being the orchitis of mumps, acute epidemic epididymo-orchitis (both virus infections), while bacterial metastatic epididymo-orchitis can occur in any severe infection, for instance in meningococcal septicaemia and pneumococcal pneumonia.

Acute epididymo-orchitis has become less common, due (1) to division of the vasa and ligation of their distal ends prior to prostatectomy (2) to antibiotic therapy particularly after operations on the urethra (including catheterization) (3) to the frequent employment of Foley's catheter in cases where an indwelling catheter is required—this eliminates the necessity for constriction of the penis by adhesive plaster and consequent retention of exudate within the lumen of the urethra (4) to the steep decline in gonococcal epididymitis, due to early antibiotic treatment.

Seeking the Cause.—An endeavour should be made to determine the cause of the infection and the organism responsible. If a specimen of urethral discharge can be obtained for bacteriological examination by milking the anterior urethra, well and good but on no account should the prostate and vesicles be massaged for this purpose in the acute stage. In every case a suitable specimen of urine should be submitted for bacteriological investigation.

Often the cause or the probable cause is apparent. In a smaller number the reason for the epididymo-orchitis is not unfolded by the history or a clinical examination, consequently the following résumé of the less frequent causes of acute epididymo-orchitis is likely to be of service

Subacute Tuberculous Epididymitis.—In cases where the vas is thickened and there is little response to the usual treatment the possibility of the infection being due to tuberculosis of the epididymis, which is not rare, must receive due consideration.

Epididymitis complicating Non-specific Urethritis is more frequent than it is in gonorrhoea, and unless correct antibiotic treatment is given early suppuration is usual. This form of infection responds best to low doses of erythromycin, 100 mg four times a day or to terramycin, 250 mg every four hours.

Epididymo-orchitis due to the Virus of Lymphogranuloma Venereum.—The infection is frequently bilateral, and is often followed by abscess formation (W E. Coutts). The diagnosis presents little difficulty because of the massive inguinal adenitis, but confirmation by the Frei intradermal test is required. Treatment with a broad-spectrum antibiotic is necessary for a month, therefore every precaution to prevent overdose must be taken.

Epididymo-orchitis due to Brucellosis (undulant, abortus, and Malta fevers) —Acute epididymo-orchitis is sometimes the first sign of these diseases. Malaise and general systemic symptoms are in evidence The diagnosis can be clarified by appropriate agglutination and skin tests, and cultures of the urine and the blood. The most effective treatment is by a combination of streptomycin and aureomycin.

Orchitis of Mumps without Parotitis occurs from time to time especially in infants. That the orchitis is due to mumps can be confirmed by a serological complement fixation test. When the differential diagnosis between orchitis of mumps, torsion of the testis, or torsion of an appendage of the testis cannot be determined there and then, the scrotal contents should be explored without delay

Traumatic Epididymo-orchitis.—When, as is often the case the patient attributes epididymo-orchitis to a strain at work, the surgeon is almost certain to become involved in the resulting litigation. If a blow on the testis or an undue strain e.g., lifting a heavy weight, can be proved, compensation is often allowed. When there is no direct injury it can be argued that an undue strain forces urine from a full bladder down the vas into the epididymis. The degree of inflammation that results depends upon whether or not the urine is infected, or whether or not there is a latent infection in the prostate or seminal vesicles. Even when there is no evidence of such pre-existing infection, there are some who are prepared to state that sterile urine forced down the vas can give rise to epididymitis. When the trauma was slight, it is right and proper for the surgeon to take the stand that the alleged accident could not have caused the epididymo-orchitis, but merely drew attention to an already existing inflammatory process that rendered the scrotal contents more sensitive than usual.

Treatment.—

General treatment: In the majority of cases of epididymo-orchitis due to a descending infection, the organisms responsible are staphylococci, *Esch. coli* and streptococci. In view of the high percentage of *Esch. coli* infections, empirical antibiotic therapy should include either streptomycin, aureomycin, or terramycin, as well as penicillin.

Analgesics.—In severe cases morphine will be required, but as a rule suitable doses of pethidine suffice

Local treatment: The patient should be confined to bed with the inflamed organ and its fellow supported on a bridge of adhesive plaster (*Fig* 939). The inflamed testis rests on a nest of cotton-wool, which for the sake of clarity is not shown in the illustration. A bed-cage is placed across the pelvis. When, by transillumination, a secondary hydrocele is clearly apparent, much relief will be afforded by aspiration of the fluid. If necessary aspiration can be repeated.

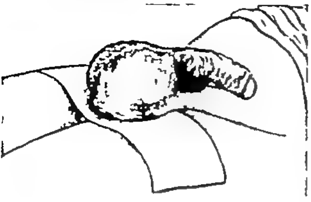

Fig 939.—A splint for the testicles. Broad adhesive plaster is employed to make the sling.

Operative treatment: Provided rest and antibiotic treatment control the inflammation, no question of operation arises. On the other hand, in cases where it seems likely that suppuration will occur comparatively early operation, say on the third day of the attack, spares the patient unnecessary suffering, recurrence, chronicity and possibly sterility. In cases where it is known that the infection will not respond to antibiotics (e.g., mumps), or when torsion of the testis cannot be ruled out, an exploratory operation should be undertaken soon after admission.

The following method of decompressing the epididymis gives excellent results. Shaving is deferred until the patient is anæsthetized, for the parts are so tender. The skin is disinfected as described on p. 689.

Technique.—The organ is explored through a lateral incision of the scrotum.

TURNER'S METHOD OF DECOMPRESSION OF THE EPIDIDYMIS

Fig 940.—An incision is made into the coverings of the testicle in order to expose the whole of the epididymis and the coverings of the vas.

Fig 941.—The coverings are peeled away, exposing the intensely inflamed epididymis, which is incised.

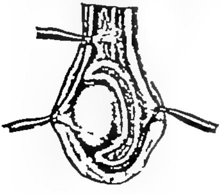

Fig 942.—The commencement of the vas is freed and its lumen catheterized.

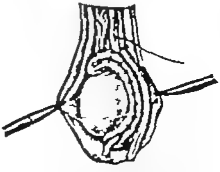

Fig 943.—A strand of nylon suture is placed in the lumen of the vas to drain pus therein. The epididymis and its coverings are drained as shown.

Step 1 (*Fig* 960).—An incision is made through the coverings of the testicle, freeing the epididymis from adhesions and allowing the commencement of the spermatic cord to be identified (*Fig* 961) The vas is separated from the other constituents of the cord and a hollow needle inserted into its lumen. Using the needle as a cannula the vas is catheterized with a strand of silkworm gut. If the vas is patent and no pus exudes, its sheath is closed with a catgut suture. *If pus is present* the silkworm gut suture is left in place and brought out through the skin at the upper angle of the wound.

Step 2.—When a secondary hydrocele is present it is incised.

Step 3.—An incision is made over the entire epididymis (*Fig* 962) which is separated from its sheath by blunt dissection The epididymis is probed systematically with a sharp instrument in search of an abscess. A piece of soft rubber drain is inserted and the sheath united over the drain (*Fig* 963) The wound is closed and the drains removed upon the third or fourth day

The immediate relief of pain which follows decompression of the epididymis and the subsequent rapid convalescence is gratifying.

Orchitis of Mumps.—No known antibiotic has any effect on the virus of mumps. Diethylstilboestrol in doses of 3–5 mg daily sometimes diminishes the pain and pyrexia. In severe cases convalescent serum is said to be efficacious. In view of the regularity with which atrophy follows this variety of acute testicular inflammation, there is little doubt that decapsulation of the epididymis should be performed more often than it is.

To be regularly effective the operation must be performed early i.e within forty-eight hours of the onset. The tunica vaginalis is exposed through a short scrotal incision the tunica opened, and the epididymis decapsulated. When the body of the testis feels stony hard and is covered with petechial hæmorrhage a short incision is made through the tunica albuginea, to relieve tension. The scrotum is drained with corrugated rubber and is supported on an adhesive plaster sling The operation relieves pain immediately reduces fever and prevents atrophy In 4 cases of this condition upon which I have operated, the epididymis was mainly involved and was plum-coloured.

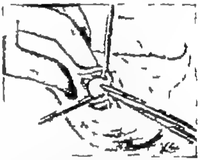

Fig 964.—Orchitis of mumps. Early incision of the tunica vaginalis only and drainage, brings about immediate amelioration of symptoms and prevents testicular atrophy (*After* N Nixon *and* D B *Lewis*.)

In a large experience of epididymo-orchitis of mumps in soldiers, D B Lewis found that by suitably infiltrating the scrotum with local anæsthetic, making a small incision over the involved testis, incising the tunica vaginalis, allowing hydrocele fluid to escape (*Fig* 964) and closing the incision around a small drainage tube resulted in immediate alleviation of pain with cessation of pyrexia within forty-eight hours.

To strengthen the hand of the surgeon who advises operation for the orchitis of mumps, it is recorded that of 19 men attending an infertility clinic, all of whom had had orchitis of mumps, 11 were aspermatic (Ballew and Masters)

ACUTE FUNICULITIS

Subacute funiculitis is endemic in many tropical countries. Occasionally the condition takes on true epidemic characteristics. However the acute form, with rapid suppuration and frequently death (if drainage is not instituted) is now almost unknown.

Essentially the lesion is a streptococcal cellulitis of the spermatic cord, with secondary thrombophlebitis of the pampiniform plexus. The clot affects the veins right up to the internal inguinal ring and often extends farther along the testicular vein. Occasionally the clot invades the inferior vena cava, when pulmonary embolism is liable to occur

Subacute endemic funiculitis is characterized by pain in the testis and isolated clots, which can be felt as tender nodules in the pampiniform plexus. These nodules are clearly separable from the vas deferens, which, however is often thickened. It is the non attachment of the nodules to the vas that makes the condition easily distinguishable from subacute tuberculous epididymitis.

When an isolated clot is situated abutting the posterior border of the body of the testis, the diagnosis can be difficult, and exploration is justifiable to rule out malignant testis. If a clotted vein is clearly visualized, unwarranted orchiectomy can be avoided.

With rest in bed, support of the testis, and antibiotic therapy resolution can be expected in nearly all cases of subacute funiculitis. Occasionally the thrombosis results in late atrophy of the testis.

IDIOPATHIC GANGRENE OF THE SCROTUM

(Fournier's Gangrene)

Idiopathic gangrene of the scrotum comes on with dramatic suddenness, the first symptom—severe pain in the scrotum—even awakening the patient from sleep. The disease is more usual in middle life but has been reported at all ages; occasionally a similar lesion occurs on a labium majus. Almost invariably the patient was in good health up to the time of the visitation. Within a few hours œdema appears; the scrotum

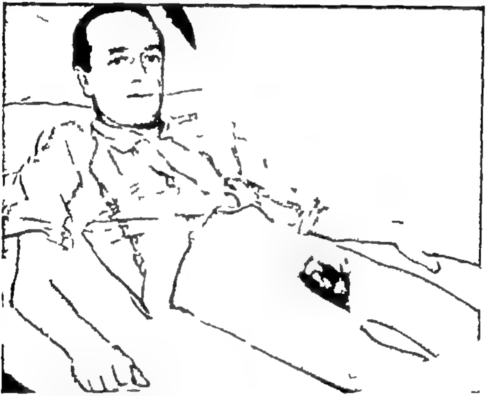

Fig. 945.—Idiopathic gangrene of the scrotum. With appropriate incisions combined with systemic penicillin therapy the infection was soon controlled. Showing the two areas where the scrotum had sloughed, leaving the testicles exposed; this photograph was taken when these areas had commenced to granulate.

becomes tense, reddened and, at a time varying from 12 hours to several days, gangrene sets in. The gangrene involves part or whole of the scrotum, and occasionally the under surface of the penis. If uncontrolled, the infection spreads along the plane beneath Colles' fascia, as in extravasation from the bulbous urethra.

Peri-urethral abscess with extravasation is ruled out by the absence of dysuria and the lack of any induration in the perineum. Notable is the extraordinary rapidity and severity of the local inflammation combined with but moderate constitutional symptoms; this should, and often does, give ample time, with present-day methods of treatment, to prevent fatal complications. The bacteriology of this remarkable disease shows an overwhelming preponderance of infections by hæmolytic streptococci. The cause of the scrotal gangrene is still a matter for speculation. It seems probable that the infection is blood-borne; once within the scrotal subcutaneous tissues the streptococci produce a violent inflammation that results in obliterative endarteritis of the arterioles supplying the overlying skin. It is the suddenness of the onset that strongly suggests a vascular disaster of infective origin.

Treatment.—In some cases penicillin in full doses has proved beneficial; however the causative organism, a hæmolytic streptococcus which sometimes can be grown aerobically, is, like the hæmolytic streptococcus that causes progressive gangrene of the

abdominal wall (see p. 178), more sensitive to bacitracin than to any other antibiotic. Therefore if it is available, pending the opportunity to submit pus to the bacteriologist and while awaiting his findings, systemic bacitracin 400 units per kilo of body weight repeated at 6-hourly intervals is the antibiotic of choice.

Unless the case is a very early one and this treatment produces improvement within 4-8 hours, the scrotum should be incised (Fig. 903). If gangrene has commenced, O. T. Mansfield recommends wide excision of all sloughing area, which saves time, rids the patient of scrotal tissue that is doomed, and stops the spread of gangrene. The excision should pass through, but not beyond, the area of erythema, thus usually preserving sufficient skin to cover the testes in due course. Excision provides the freest possible drainage. Although the testes are often denuded to their tunicæ albugineæ, they remain undamaged. As to local treatment, the newest and probably the best is a solution of bacitracin 500 units per ml., applied on gauze. Streptokinase and streptodornase (see p. 140) have also given good results. When the inflammation has died down completely and the patient's general condition is entirely satisfactory, secondary suture should be undertaken. In most cases the freshened edges of the elastic scrotal skin can be brought together over the testes. Exceptionally a plastic procedure will be required. Because epithelialization was not progressing satisfactorily J. F. Thomes implanted the testes into the thighs on the nineteenth day. *He advises this procedure in like cases in men over 35 where fertility is not of prime importance.*

Prognosis.—During the past ten years the mortality has fallen from over 30 per cent to under 10 per cent.

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CHAPTER LXI

OXYGEN THERAPY

Transportation of Oxygen from the Lungs to the Tissues.—Under physiological conditions while the blood passes through the lungs the oxygen tension in the pulmonary capillary blood rises to, or almost to that of the inspired air viz., 20.93 per cent at sea level: each 100 ml. of blood contains 15 mg *of hæmoglobin which is capable of carrying* 20 ml. of oxygen (saturation point). Under normal conditions arterial blood leaves the heart saturated almost fully (97.5 per cent). In addition, a small amount (0·3 per cent) is held in suspension by the plasma. Under resting conditions venous blood contains 14 ml. of oxygen per 100 ml., which shows that when the body is at rest only a small proportion of the available blood-oxygen is consumed by the tissues. On the other hand, when vigorous exercise is taken as much as an additional 7 ml. of oxygen is utilised. Similarly there is a proportional increase in the consumption of oxygen by the tissues in pathological states which raises the metabolic rate (pyrexia, hyperthyroidism).

Since very little oxygen leaves the blood while it is in the pulmonary vein, in the left heart or in the systemic arterial tree arterial blood provides a means of measuring the actual oxygen tension of blood leaving the lungs. The degree of arterial anoxæmia can be determined accurately only by direct analysis of arterial blood.

Fig. 966.—Riley's needle for arterial puncture. The needle is inserted with the stilette withdrawn just behind the point of the needle. After the artery has been entered the stilette is advanced to its fullest extent so that the needle can be advanced preceded by the probe end of the stilette which minimises damage to the intima.

Obtaining a Sample of Arterial Blood for Analysis.—There is a reticence concerning the performance of arterial puncture—it is envisaged as a *painful* process followed by a high percentage of hæmatomata, with even a possibility of engendering a traumatic aneurysm. This is not true and thousands of arterial punctures have been performed with no more difficulty or untoward sequelæ than venepuncture. The femoral artery is the simplest to puncture, although the brachial, radial, or even the carotid can be used. The skin and deeper tissues around the artery are infiltrated with 1 per cent solution of procaine to reduce arterial spasm and prevent pain. The needle used must be sharp and 20–23 gauge. It should be tested carefully for the presence of a hooked tip by drawing it over sterile cotton-wool. It is an advantage to employ a special needle for arterial puncture—Riley's needle (*Fig.* 966).

The syringe, which should be an all-glass 10-ml. one, is filled with heparin solution (5000 units per ml.). The piston is depressed so as to empty the syringe, leaving the dead space in the needle filled with the solution. When the needle enters the lumen of the artery blood is immediately forced into the syringe with sufficient pressure to push the piston up the barrel. Four ml. is a sufficient quantity to withdraw. The needle is removed, and digital pressure is maintained by an assistant for a minute, after which a pressure bandage is applied for a short while—ten minutes is ample. To prevent exposure of the contents of the syringe to air at the earliest possible moment after withdrawing the blood ¼–½ ml *of mercury is drawn into the syringe,* which is sealed with a hub cap, and shaken vigorously to ensure even distribution of the anticoagulant. The syringe is then placed in a bowl of iced water and sent to the laboratory for immediate analysis.

At the present time an effort is being made to place oxygen therapy on a scientific basis. As will be shown, the empirical administration of oxygen leaves much to be desired, for the clinical signs of anoxæmia are often misleading. Most hospital laboratories can undertake a determination of the oxygen tension of arterial blood.

ANOXIA

By anoxia is meant a deficient supply of oxygen to the tissues. The term anoxæmia as commonly used, has the same meaning though literally this signifies a lack of oxygen in the blood. *There are three types of anoxia, according to the cause producing the condition.*

Anoxic Anoxia is a state of diminished oxygen tension in the arterial blood. It always involves deficient saturation of the hæmoglobin with oxygen. The causes of anoxic anoxia met with in surgical practice are:—

1. *Obstruction to the Air Passages.* The first consideration is to remove the obstruction; oxygen therapy is of secondary importance.

2. *Exudate filling the Alveoli.*—Removal of the exudate by postural drainage if possible, otherwise by suction via an endotracheal tube, a bronchoscope, or a tracheostomy is of greater importance than oxygen therapy.

3. *Atelectasis.*—Postural percussion drainage is the most important step in treatment (See p. 140.)

4. *Pressure on the Alveoli* by a pleural effusion, hæmothorax, pyothorax, or pneumothorax. When any of these lesions is unilateral, anoxia is usually transitory. While oxygen therapy is a valuable adjunct if dyspnœa is present, no time should be lost before aspirating the fluid or air.

5. *In Bronchopneumonia.*—When there are patches of consolidation scattered throughout the lungs oxygen therapy can prove life-saving.

6. *In Lobar Pneumonia* the value of oxygen therapy is doubtful, but as there are likely to be some areas where the consolidation is incomplete, it is possible that it will prove of some benefit. If the patient is cyanosed, the best course is to give it a trial; if the patient dislikes the procedure, or it prevents sleep, it should be discontinued (R. V. Christie).

7. *Pulmonary Œdema.*—Fluid exudes from the lungs, and is churned into foam by laboured respirations, thereby blocking the small, and eventually the large, bronchi. A. L. Barach finds that if 100 per cent oxygen is given with the exhalation valve set to give a predetermined pressure of 5 cm. of water, frequently there results a remarkable clearing of acute pulmonary œdema.

8. *Insufficient Action of the Respiratory Muscles* due to peripheral causes, e.g., stove-in chest, flail chest, action of curare-like drugs, are all conditions in which oxygen therapy is invaluable.

9. *Depression of the Respiratory Centre,* e.g., alkalæmia from persistent vomiting or long-continued gastro-intestinal aspiration, morphinization, increased intracranial pressure. Again, in all these conditions oxygen therapy is of service.

Anoxic anoxia is particularly harmful because the cells of the body are sensitive with regard to the pressure at which the oxygen is available. This, in itself, is an impediment to oxidative processes within the cells, let alone the subnormal supply of oxygen carried to them by the unsaturated hæmoglobin. In many instances oxygen therapy will supply what is needed—a normal oxygen tension of the arterial blood.

Anæmic Anoxia.—The chief surgical cause of this variety is severe hæmorrhage. Given the same amount of oxygen in the blood, the effects of this variety are not so injurious as those of anoxic anoxia, because the tension of whatever oxygen the blood contains is normal. What is essential in the treatment of this condition is a substantial increase in the oxygen-carrying content of the blood. Transfusion of whole blood or packed red cells, and when possible stopping the hæmorrhage, is the true remedy. While blood is being obtained, and after infusion of a blood substitute has been commenced, the inhalation of 100 per cent oxygen is of value. Some of it will reach the capillaries in the plasma.

Stagnant Anoxia is due to a deficient amount of blood circulating per minute. It is caused by heart failure or shock (peripheral circulatory failure). As in the anæmic type, the oxygen tension in the arterial blood is normal.

While oxygen therapy is indicated in the case of heart failure because of the concomitant pulmonary congestion, it is of little value in peripheral circulatory failure because it is the *transportation* of oxygen from the lungs to the heart that is at fault, but in high concentrations it sometimes leads to clinical improvement. This is due solely to the increased load of oxygen carried in the plasma.

The Clinical Signs of Anoxia.—The leading signs of anoxia are cyanosis, dyspnœa, and a fast pulse-rate. These will be discussed with special reference to their value and to differential diagnosis:—

Cyanosis.—The carbon dioxide content of the blood has no bearing whatsoever upon cyanosis, the most usual form of which is dependent solely upon inadequate oxygenation of the hæmoglobin of the blood. It should be noted particularly that although the causes

of cyanosis are in general similar to those of anoxia, cyanosis is not by any means always an accurate index of the severity of the anoxia present. For instance when the hæmoglobin content of the blood is as low as 30 per cent, corresponding to less than 5 G per 100 ml of blood, cyanosis would not appear even if all the hæmoglobin were in the reduced state for a minimum of 5 G of unoxygenated hæmoglobin per 100 ml. of blood is required to produce visible cyanosis. Again, peripheral vasoconstriction, by reducing the amount of blood in the surface vessels, is wont to prevent cyanosis being perceived, even though a dangerous degree of anoxia is present. Thus it is evident that severe oxygen want can be present without cyanosis, and conversely cyanosis due to cold, producing local stagnant capillary anoxia can be most evident in the lips, nose, hands, and feet without arterial anoxia. Furthermore a matter of serious import is that even experienced clinicians vary in their ability to recognize minor degrees of cyanosis. Unlike, for instance the pulse-rate which is a matter of careful counting the recognition of cyanosis depends on colour perception, which is subject to wide variations ; even so, daylight, or artificial daylight, is essential.

Provided the patient has a free airway and retained bronchial secretions, if present, are removed as soon as possible anoxæmic cyanosis is the most important indication for oxygen therapy

Sulphonamide cyanosis Cyanosis of varying intensity is observed in a percentage of patients undergoing sulphonamide therapy The cyanosis is unaccompanied by a decrease in the oxygen-carrying capacity of the blood. It is believed that the phenomenon is due to a dark oxidation product of the drug which stains the red blood-cells. There is no special treatment and the condition, which often lasts more than a week, is not dangerous.

Hyperpnœa Dyspnœa —Although anoxic anoxia, acting through the chemoreceptors (carotid and aortic sinuses) causes afferent impulses to ascend to the respiratory centre thereby causing a moderate increase of the rate and depth of respiration the greater stimulus to the respiratory centre is increase of the hydrogen ion content of the blood due in many instances, to CO_2 retention. The causes of dyspnœa are varied, and treatment clearly depends on the cause

Dyspnœa due to CO_2 retention Often this is caused by obstruction to the air-passages, and while oxygen therapy is a valuable accessory the main effort should be directed to the relief of respiratory obstruction. Too frequently oxygen is administered when the call is for the insertion of an airway endotracheal catheterisation or tracheostomy in the case of upper respiratory obstruction, postural drainage and possibly venesection in the case of pulmonary œdema, postural percussion drainage in the case of atelectasis, or intratracheal or bronchoscopic suction when the bronchial tree is full of mucopus that cannot be coughed up.

Reflex dyspnœa Overdistension of the lungs calls into action the Hering-Breuer (stretch) reflex, by which inspiration is inhibited when the lung is full of air When a portion of the lung or lungs is more rigid than normal, as occurs in consolidation reflex limitation of inspiration causes earlier starting of the next breath. This results in rapid, shallow breathing The dyspnœa of pneumonia, pulmonary œdema, and pulmonary infarction is largely reflex in origin, as also is the dyspnœa which accompanies atelectasis. Although when a large area of lung is involved there may be an element of anoxia, in which case oxygen therapy is advantageous, it is in these cases particularly that without at least an initial estimation of the oxygen content of the arterial blood, one cannot be certain if oxygen therapy is required.

Dyspnœa due to pulmonary hypertension e.g., mitral stenosis, severe bronchitis, advanced emphysema, and left ventricle failure is characterized by orthopnœa. The patient will not only sit up, but will endeavour to hang his legs over the side of the bed as well. The sitting posture allows the diaphragm to descend more easily relieves pulmonary congestion by retaining blood in the abdominal viscera and lowers the pressure in the pulmonary vascular bed. This form of dyspnœa may be partly reflex, but is mainly anoxic due to pulmonary congestion. In many cases oxygen therapy brings considerable but not always complete relief Aminophylline and diuretics may help.

Air hunger In most surgical writings is linked particularly with catastrophic hæmorrhage A sudden loss of a large quantity of blood, by lowering the blood pressure stimulates the nerve-endings of the carotid and aortic sinuses, causing afferent impulses to ascend to the respiratory centre—any sudden fall of blood pressure e.g. shock, provides this stimulus. To be of any value 100 per cent oxygen must be given, but the all-important urgent matter is to replenish the circulation and stop the hæmorrhage if present.

The hyperpnœa of acidæmia complicating uræmia is related to one of the non-oxidation functions of the respiratory system namely acid base balance The purpose of overbreathing is to eliminate as much as possible of the acid substance CO_2. The treatment of acidæmia is discussed on p. 603. Oxygen therapy is useless the same is true for acidæmia due to the ketosis of diabetes.

Dyspnœa due to cerebral injuries: World opinion is veering to the performance of early tracheostomy and intermittent aspiration of bronchial secretions through the tracheostomy opening Oxygen can be given with advantage via the tracheostomy opening as required.

From these facts there emerge two conclusions —

1 The indication for oxygen therapy is not hyperpnœa or dyspnœa, but anoxia. Anoxia can occur without hyperpnœa or dyspnœa Hyperpnœa or dyspnœa can occur without anoxia.

2. When oxygen therapy is given to a patient with anoxia and dyspnœa it should not be discontinued because the administration of oxygen fails to relieve the dyspnœa. Rather this should be taken to signify that the dyspnœa is due to a cause unrelated to anoxia, e.g., the stretch reflex.

Pulse-rate.—Acceleration of the pulse-rate occurs in anoxia, but so many other factors may be the cause of increased rate in an ill patient that it is impossible to assess the rather small increase due to acute anoxia. It is probably correct to state that a diagnosis of acute anoxia can be confirmed if the pulse-rate decreases by ten beats or more within ten minutes of commencing oxygen therapy

Restlessness.—Anoxic, dyspnœic patients are often restless. Regardless of the cause morphine is often given for restlessness; this is permissible when the restlessness is caused by pain, but it is certainly contra indicated if the restlessness is due to anoxia, because morphine seriously depresses the respiratory centre Morphine may be very dangerous in emphysematous subjects.

The Indications for Oxygen Therapy.—Throughout this book, when oxygen therapy is indicated the fact is recorded in the subject under discussion In this chapter attention is drawn to the dictum that it is much easier to prevent anoxia by oxygen therapy than to treat the established state. It is especially important to prevent anoxia in the dangerous period when the patient is recovering from a general anæsthetic. At this time shallow breathing is accompanied by retention of carbon dioxide which, in high concentrations, produces narcosis and poisons the respiratory centre With a rising CO_2 blood content the pulse may be deceptively good. If there is delay in recovery of consciousness the anæsthetist will ventilate the lungs through an endotracheal catheter by pressure on the anæsthetic bag a soda lime canister is provided in the circuit to absorb the CO_2. With returning consciousness the patient should be permitted to breathe room air as this contains the correct quantity of CO_2 to stimulate the respiratory centre and a high nitrogen content that militates against the development of atelectasis (see p. 145)

If there is any evidence of anoxia the administration of oxygen is indicated in all patients unconscious as the result of injury Cyanosis is an absolute indication, but anoxia may be present when cyanosis is not detectable by clinical means; in the unconscious shallow breathing suggests depression of the respiratory centre, while hyperventilation is evidence of overstimulation of the centre. It is in these cases that an analysis of the oxygen content of the arterial blood is so helpful in confirming or disproving that the patient needs oxygen therapy

The signs that call for oxygen administration in the conscious patient, viz., cyanosis, dyspnœa, and a fast pulse-rate have been discussed already

It cannot be reiterated too often that at all times the airway must be clear It is no good giving oxygen to a patient whose tracheobronchial tree is obstructed by fluid or muco-pus such a state demands either intratracheal or bronchoscopic suction, or in the absence of a skilled bronchoscopist tracheostomy

ADMINISTRATION

Danger of Explosion or Fire.—Oxygen itself does not burn, but in its presence any inflammable object burns more readily and more vigorously than in air Oxygen therapy should therefore not be conducted in the presence of any source of ignition. The following are examples of what must not be allowed in the vicinity of a patient undergoing oxygen therapy: smoking matches, electric light and power switches, night lights, static sparks

from combing the hair vigorously or from nylon nightwear The most dangerous practice of all is to grease the screw fitting on the oxygen cylinder to facilitate the screwing in of a regulator Oxygen and grease under pressure do not merely burn—they cause an explosion.

Oxygen Cylinders.—The British standard marking for oxygen cylinders is black with a white shoulder They are supplied in cylinders of 24 48 120 and 180 cu. ft. capacity It is necessary to know how long a cylinder in use will last. If F equals the number of cubic feet in the cylinder and M equals the number of litres per minute of flow then the cylinder will last F/2M hours. A full cylinder of oxygen gives a definite ring when tapped, but a pressure gauge is the only reliable means of knowing how much oxygen it contains. *The volume (number of cu. ft.) is proportional to the pressure which* when the cylinder is full is 1800 lb. per sq in. A half full cylinder will therefore register 900 lb. per sq in.

Fig 967 —A wet flow meter

A **Humidifier**—As dry oxygen is irritating to the respiratory membrane, no matter what device is employed to administer it the oxygen must be humidified by passing it through water contained in an air tight bottle and warmed the water in the bottle must be kept at the correct level When a flow meter is not available a rough estimate of the rate of flow can be ascertained as the oxygen bubbles through the humidifier When the bubbles cannot be counted, the rate of flow is about a litre a minute

A wet flow meter (Fig 967) can be made easily Through the cork of a wide-mouthed bottle a tube (A) made of copper or any metal is inserted, and this is the inlet tube, which is graduated with a series of five 1-mm. *holes at the distal end B is a glass outlet tube, while C is an additional tube which acts as a* safety valve Within reasonable bounds, the bore of the tube is immaterial It is the size and spacing of the guide holes that matter Efficient humidifiers are provided with artificial respirators used in the treatment of poliomyelitis. A wet flow meter is shown in use in *Fig* 960

Choice of Method.—Oxygen can be administered through nasal catheters, by an oxygen mask, or by placing the patient in an oxygen tent.

Intranasal Catheters—This method is more effective than is usually conceded. With a good-sized soft catheter the method is not uncomfortable and 6 litres a minute of moistened oxygen which doubles the oxygen content of inspired air (normal 20·96 per cent), can be

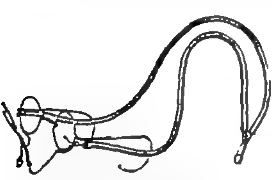
Fig 968.—Tudor Edwards spectacle carrier for the intranasal administration of oxygen


Fig 969 —The same in use

maintained effectively and safely The catheters can be retained by pieces of adhesive strapping but far more comfortable and efficient is to support them by Tudor Edwards's spectacle frames (*Figs* 968 969). In order to attain the desired result, attention must be directed to details. The catheter for adults should be sizes 12 to 14 Jacques, with several holes cut to within half an inch (1 3 cm.) of their tips. The catheters must be placed properly If inserted too far the patient tends to swallow the oxygen; if not far enough, the concentration of the oxygen in the lungs is reduced. A good method is to measure the distance from the nares to the tragus (usually about 5 in. (12 5 cm.)) and mark this on each catheter before its insertion. *The nurse must be instructed to keep the mark at the level* of the nostrils. Nasal catheters should be well lubricated with percaine (nupercaine[1]) jelly

[1] Ciba Laboratories Ltd., Horsham, Sussex.

as otherwise their presence will irritate the patient considerably. Nasal catheters must be changed every 24 hours.

Oropharyngeal intubation: Especially when no mask or oxygen spectacles are available a catheter passed into the oropharynx, and maintained there, enables a concentration in excess of 45 per cent oxygen to be maintained with a flow of 6 litres per minute. The size of the catheter, the mode of cutting holes, and its lubrication are the same as that described. It is inserted into the nose and from thence into the oropharynx, until the patient begins to swallow oxygen. It is then withdrawn slowly until the patient stops swallowing, when it is fastened securely to the nose and forehead. Placed by this method, the tip of the catheter will lie just behind the uvula (*Fig.* 970). It is essential that the catheter should be strapped very securely, otherwise should it slip farther down the pharynx than intended, a considerable amount of oxygen will be swallowed. The position of the catheter in relation to the external naris is marked on the catheter with ink. The catheter is changed at 12-hourly intervals to the contralateral nostril.

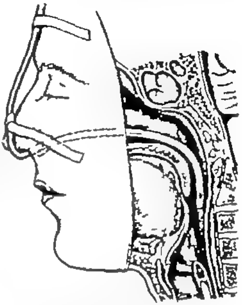

Fig. 970.—Showing the position of the catheter in the oropharynx, and the important method of securing it in this position.

Oxygen Masks.—A variety of masks have been marketed; most of them are made in two types:—

1. Oronasal, that covers the nose and the mouth, and
2. Nasal, that covers the nose only.

The former are desirable in maintaining a high concentration of oxygen because the patient can breathe through the mouth if he so desires; when the patient is unconscious an oronasal mask is essential.

In distressed conscious individuals the nasal type is often better tolerated. It also has the obvious advantage that the patient can be fed without removing the mask.

The Barach Eckman (injector) mask[1] is provided with an oxygen concentration meter that screws into the cylinder head. This is a chamber to which the oxygen is admitted

Fig. 971.—The Barach Eckman mask (nasal type) in use.

through a restricted orifice. A negative pressure is created at the rear of the chamber where there is a disk with different-sized openings to admit air. By turning the disk to the appropriate number the concentration of oxygen can be varied from 10 to 100 per cent. The advantages of the Barach-Eckman mask (*Fig.* 971) over the B.L.B. mask[2] are that the percentage of oxygen is governed by an oxygen concentration meter (the

[1] Made by the O. E. M. Corporation, Fitch Street, Norwalk, Connecticut, U.S.A.
[2] B.L.B.—Boothby, Lovelace and Bulbulian.

injector). Oxygen passing through the injector takes in air so that a mixture of a constant composition enters the patient's lungs. Concentrations are controlled at the orifice that admits air viz., if a small opening is chosen a correspondingly high concentration of oxygen is administered. With this type of mask the whole of the exhaled air passes into the surrounding atmosphere by the provision of an expiratory valve on the face-piece as well as a mica inspiratory valve at the entrance of the collecting bag. Consequently there is no re breathing into the bag and the CO_2 percentage in the mask is not higher than 0·1–0·2 per cent which is ten times lower than in the B.L.B. mask (C Ogilvie). Should the bag collapse completely there is a safety valve which opens to admit outside air until the bag re-inflates. Barach recommends increasing rate of flow of the oxygen gradually until the desired concentration is reached this minimizes intolerance to the mask, and obviates unpleasant sequelæ.

The Polymask[1] *(Fig 972)* is a very light double bag made of polyvinyl chloride The smaller inner bag communicates through two holes 12 mm. in diameter with the larger outer bag into which oxygen flows. Oxygen is drawn through the large holes during inspiration. Expiration takes place chiefly through two holes 6 mm. in diameter which connect the inner bag with the surrounding atmosphere

Fig 972.—The Polymask in use
(Photograph by Mr F Dee Birmingham)

When the patient inspires, some air is drawn through the expiration holes ; nevertheless, provided oxygen is entering the mask at about 8 litres per minute and the patient is not grossly hyperventilating this diluting effect is small. A metal malleable strip is incorporated into the rim of the mask, to facilitate its adaptation to the contour of the face. The mask is held in place by an elastic band which is passed over the back of the patient's head. Some care is necessary in fitting the mask, especially in unconscious patients the chin should be inserted into the mask first, and then the malleable metal strip moulded to fit over the nose very closely The Polymask is suitable for any patient requiring not more than 60 per cent oxygen in the alveolar air It is particularly useful in unconscious and uncooperative patients. An occasion where it is invaluable is when a deeply unconscious patient must be transported some distance from the operating theatre to his bed. Of course the mask must be removed for oral feeding but in general it can be worn without discomfort for long periods, and it is cheap enough to be thrown away after use

In Oxygen Tent[2] is expensive to purchase or to hire[3] and the amount of oxygen consumed is great Oxygen tents require a high oxygen flow rate to ensure not only that the required oxygen concentration is maintained but also that carbon dioxide is eliminated adequately Because of leakages, it is often inefficient in maintaining the correct oxygen level. Many models generate heat and one source of oxygen supply must be run through an ice-chamber The surgical patient, in particular cannot with safety be isolated in a tent where he is inaccessible for such procedures as blood transfusion and gastric aspiration, as well as constant nursing attention. A patient left in a tent without expert supervision may have shallow respiration and in spite of a good colour is liable to develop a high degree of carbon dioxide retention this condition may produce severe mental disturbance In surgical practice oxygen tents are being used less and less, except in children who will tolerate neither a mask nor nasal tubes.

Intragastric Oxygen[4] **for the Newborn.**—Two Jacques catheters, sizes 3 and 5 and glass connexions *to fit are required. The larger catheter is passed and the stomach*

[1] A Polymask is also available in which the inlet tube diameter has been increased to ½ in. (1 3 cm.) to enable aerosols to be administered when the Polymask is in use
[2] British Oxygen Gases Ltd., Great West Road, Brentford, Middlesex.
[3] Oxygen tent can be hired from Oxygenaire Ltd., branches in most of the large cities of England.
[4] Founded on the fact that in some fish respiration is entirely alimentary

contents aspirated. The bell end of the catheter is placed under water in a beaker. The smaller (inlet) catheter, connected to the pressure tubing of an oxygen cylinder with oxygen running at 1 litre a minute, is then also passed into the stomach. Within a few seconds a stream of oxygen bubbles passing through the water in the beaker (*Fig.* 973) shows that the oxygen is entering and leaving the stomach. The catheters are left in until adequate spontaneous breathing is established. Although the oxygen causes the abdomen to bulge, the distension is not great with an oxygen flow of 1 litre per minute. The oxygen is absorbed direct into the blood-stream from the capillaries of the gastric and jejunal mucous membrane.

Difficulties in the Administration of Oxygen.—It is not unusual for a patient desperately in need of oxygen, actively to resist oxygen therapy. Masks or nasal catheters are swept from the face, and an oxygen tent is pulled from its moorings. Sedation is sometimes essential before oxygen can be given. Paraldehyde, which does not depress the respiratory centre, is the safest drug to employ.

The Goal of Oxygen Therapy in acute anoxæmia is to increase the arterial saturation to normal. If 40 per cent oxygen will accomplish this purpose, there is no need to give a higher percentage. If sufficient increase in arterial oxygen saturation is not attained following the inhalation of 40 per cent oxygen, then 60, 80, or 100 per cent should be administered. It is evident from the shape of the oxygen dissociation curve (*Fig.* 974)

Fig. 972.—Intragastric administration of oxygen in a newborn infant with asphyxia neonatorum. (*After* Y. *Akerrén.*)

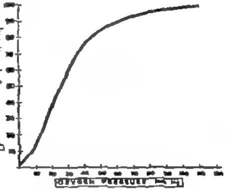

Fig. 974.—Oxygen dissociation curve of human hæmoglobin at sea level. (*After* Dill.)

that in cases of grave anoxic anoxia a large increase in oxygen saturation can be obtained by a comparatively small increase in the concentration of oxygen. In an anoxæmic patient in whom recovery depends to a large degree on oxygen therapy, the effectiveness of the administration should be checked, at least initially, by a direct determination of arterial oxygen saturation.

100 per cent Oxygen is required but seldom. In conjunction with the other methods, it may prove to be the breath of life in cardiac arrest (see p. 92), blue asphyxia under anæsthesia (see p. 99), air embolism (see p. 100), or œdema of the lungs. It is also possibly of value in displacing nitrogen in paralytic ileus (see p. 464) and for expediting the absorption of surgical emphysema (see p. 723). Possibly it is of some help in keeping the patient alive while awaiting blood transfusion in exsanguination. Lastly, it can be of help in some cases of profound shock, especially if the patient has sustained a thoracic injury or is under the influence of heavy morphinization. Shocked patients requiring oxygen (*Fig.* 975) frequently need it for 48 hours. One patient, therefore, may require as much as 10 to 20 oxygen cylinders of 48 cu. ft. capacity. Thus it will be realized that continuous oxygen therapy is a very costly process, but it is often harmful to attempt to economize.

As has been explained in the last two examples, one cannot hope that the extra oxygen will be carried by the available hæmoglobin which is saturated by the patient with undamaged lungs breathing atmospheric air, but it is possible that by administering 100 per cent oxygen an increased load of oxygen (normal 0.3 per cent) will be conveyed to the oxygen-starved tissues by the plasma. The tissues first to suffer from oxygen deprivation are the

cerebral tissues, the second is the myocardium. Attention is drawn to the prevention and treatment of cerebral œdema by intravenous sucrose when severe oxygen deprivation has lasted for more than three minutes (*see* p. 98).

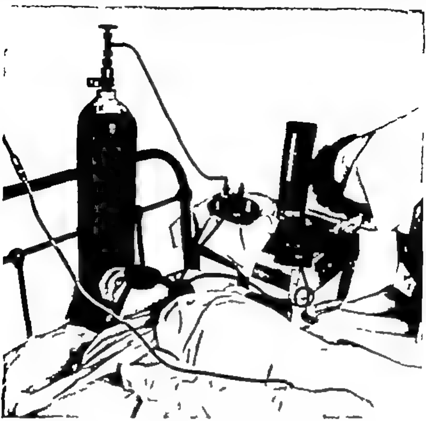

Fig. 975.—Oxygen therapy in progress in a case of shock consequent upon multiple fractures, including fractured pelvis. The sister is recording the blood pressure.

POSSIBLE BANEFUL EFFECTS FROM THE ADMINISTRATION OF OXYGEN

1. Sequelæ of the Elimination of Nitrogen.—*a.* When the lungs are filled with oxygen and some of the alveoli become obstructed, as occurs frequently during or after the administration of a general anæsthetic, atelectasis is more apt to develop than if the lungs contain the usual 79 per cent of nitrogen. This is due to the fact that the pulmonary circulation absorbs all the oxygen from the obstructed alveoli quickly.

b. In the same way, if the Eustachian tubes become occluded during the administration of oxygen, absorption of the oxygen from the middle ear is liable to lead to retraction of the tympanic membrane and earache. This complication is very common following oxygen therapy of over 24 hours' duration.

c. Likewise absorption of oxygen from obstructed paranasal sinuses gives rise to a vacuum headache. Dense opacity of the paranasal sinuses confirms the diagnosis.

2. Substernal Pain is often noted in patients receiving over 70 per cent of oxygen for more than sixteen hours. The pain is aggravated by removal of the mask, and continues for some hours, and then slowly passes off. The cause has not been elucidated, but the distribution of the pain suggests tracheobronchitis.

3. Mental Symptoms are particularly liable to develop in patients suffering from pulmonary emphysema who are undergoing oxygen therapy in high concentration. The only prevention is to discontinue the oxygen or reduce its concentration very considerably for, say, a quarter of an hour, six hourly.

4. Pulmonary Œdema due to Long-continued Administration of 100 per cent Oxygen.—100 per cent oxygen is administered by an oronasal mask, which must be removed from time to time for feeding and washing the patient. This, in itself, is a safeguard against oxygen poisoning. No deleterious effect has been observed when high concentrations of oxygen have

been continued for 48 hours. After that time a close watch must be kept on the lungs for signs of pulmonary œdema. If this develops, by increasing the pressure of oxygen 1 cm. of water every four hours until 4 cm. of water in expiration is registered the œdema clears (A. L. Barach). After that the therapy must be discontinued gradually and stopped as soon as it is safe to do so.

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CHAPTER LXII

THE LUNGS AND PLEURAL CAVITIES

ASPIRATION OF THE CHEST

Even if the physical signs of fluid in the thorax are unquestionable the surgeon will be wise whenever possible, to have anteroposterior and lateral radiographs available before deciding to explore the pleural cavity

Aspiration of the chest is not infrequently required for an effusion. Such an effusion due to injury or disease of the underlying lung can be traumatic pyogenic tuberculous or malignant also it can arise as a complication of a subdiaphragmatic abscess.

The aim of aspiration is either —

1 Diagnostic or

2. Therapeutic (*a*) *To relieve intrathoracic pressure causing grave dyspnœa*; or (*b*) *to remove infected fluid that is giving rise to toxæmia* or

3. Both diagnostic and therapeutic

Diagnostic aspiration determines the character of the fluid and enables an assessment of the susceptibility of any organisms present to antibiotics to be determined.

Armamentarium.—In addition to a 20-ml syringe a hypodermic needle an intra muscular needle, and a selection of aspirating needles together with a supply of local anæsthetic—1 per cent procaine for an adult, ½ per cent for a child and ¼ per cent for an

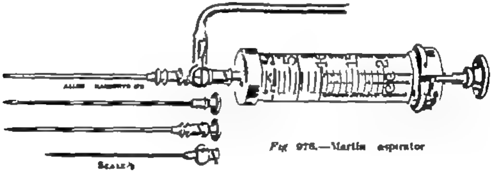

Fig 976.—Martin aspirator

infant it is absolutely essential to be provided with a two-way tap between the syringe and the needle *The ideal outfit for aspirating* the pleural cavity is Martin's aspirator (*Fig* 976).

The entry of air into the pleural cavity at the time of aspiration is to be avoided rigorously for it favours collapse of the lung and spread of the infection. Without the use of a two-way tap air is bound to enter the pleural cavity when the full syringe is disconnected t empty it.

PARACENTESIS

A sedative should be give ... ur before the punct

Position of the Patient.— ... rtable position ... as well as the most satisfactory for the opera ... patient to be ... leaning forwards with the arms resting on a b ... 977). An imp ... of this posture is that the scapulæ are carried ... not overlap ... are Wh ... bed table is available Scadding ... 978) I useful.

Site.—Normally in the fi ... puncture is ... the 8th Interc ... in the area between th ... of the midax ... 8th is ... les immediately b ... when the

Local ... le weal is ... pro

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space so that by diffusion the intercostal nerve will be anæsthetized. When it is anticipated that there will be difficulty in locating the fluid within the pleural cavity it is well to anæsthetize two spaces, making the injection well towards the spine this will render a wider area insensitive

Introduction of the Aspirating Needle—The syringe to which the needle is connected should contain a few ml. of the anæsthetic solution, so that in the case of a dry puncture when the pull on the piston is released the plunger cannot fly back against the base of the

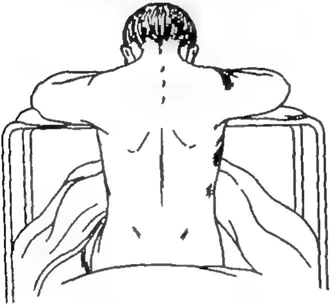

Fig 977—A good posture for aspirating the thorax. (*After Holmes Sellers.*)

Fig 978.—Straddling position for needling and aspirating the chest.

syringe and break the barrel. When the normal pleura is penetrated it offers no more resistance than a sheet of notepaper When the pleura is thickened the resistance encountered is correspondingly increased. As soon as the needle has passed through the pleura the plunger is withdrawn.

Fluid is drawn into the Barrel of the Syringe—If purulent, the appearance of the fluid gives some clue as to the infecting organism. Streptococcal and staphylococcal pus in the early stages of infection is thin and white although a very virulent streptococcal effusion

is sometimes transparent, but slightly blood-stained. Thick, creamy pus of a greenish-yellow hue is characteristic of a pneumococcal infection.

As the first syringeful of aspirate is contaminated with procaine solution, after having turned the tap appropriately it should be rejected by discharging it into a receiver. The second syringeful is delivered into a sterile test tube for transference at the earliest opportunity to the bacteriological department. The third syringeful is also discharged into a test tube to be retained by the clinician, and allowed to stand in a rack overnight. The relative amount of opaque pus and supernatant fluid (*Fig.* 979) can be compared with subsequent specimens, with great advantage.

Therapeutic Aspiration.—The fluid should be aspirated steadily but rather slowly, 20–30 minutes being taken to remove a large collection. Provided the patient does not exhibit any untoward symptom aspiration should be as complete as possible. If the patient is in tolerably good condition, it is safe to withdraw as much as 700–800 ml. of fluid. At the conclusion of the aspiration 200 000–300,000 units of penicillin in 10 ml. of saline solution are injected into the pleural cavity as a prophylactic or curative measure. After withdrawing the needle and sealing the puncture the area around the puncture should be ringed with a small circle of dye—methylene blue—and the depth of the needle puncture recorded.

Fig. 979.—Showing thick pus in aspirated fluid after standing overnight.

Dangers.—

Untoward Symptoms.—If the patient feels faint, complains of dyspnoea or tightness in the chest, or begins to cough, aspiration should be discontinued forthwith.

Pleural Shock.—A pleural reflex via the vagus is possible but is most improbable if local anæsthesia is employed. Cardiac arrest from this cause has been reported, but as most of the cases occurred during the induction of a pneumothorax, air embolism is the more probable explanation of the catastrophe.

Difficulties.—

Fluid is not located.—In order to cover a wide area, it is useful to make the first puncture at right angles to the thoracic wall, and then to work systematically in a radiating fashion until the whole of the area within reach of that puncture has been explored. When this is unsuccessful, puncture of another space must be performed—usually the one above. Provided each area is anæsthetized properly four punctures are permissible without distressing the patient unduly. It is unwise to enter the needle below the 9th space because a needle inserted into either the 10th or the 11th space is so liable to pierce the diaphragm. If it is essential to explore these spaces the needle should be introduced in an upward direction and for a short distance only. When the clinical and radiographic findings point to the existence of an empyema, diagnostic aspiration must be repeated daily until pus is found, or proved to be absent by all means available.

Blood is withdrawn.—Puncture of the lung is usually accompanied by a little blood and more air which combine to make a froth. The aspiration of pure blood signifies (*a*) Entry into a hæmothorax. (*b*) Penetration of an intercostal vessel so that the tip of the needle lies within its lumen—an unusual happening. The differentiation between these two conditions can be made by assessing where the point of the needle lies.

Liver puncture often results in some tiny fragments of brown liver substance being withdrawn; if present they can be demonstrated by evacuating the contents of the syringe and needle on to dry gauze.

Gas is withdrawn.—This must signify one of four things: (1) A faulty junction in the apparatus permitting the entry of air. (2) Puncture of a hollow viscus. (3) Puncture of the lung which, as has been shown, is accompanied by at least some bloody foam. (4) Gas from an empyema cavity: the odour of the last leaves no doubt as to its origin, and by continuing to aspirate it is probable that pus will be withdrawn.

THE TREATMENT OF EMPYEMA BY ASPIRATION AND ANTIBIOTIC THERAPY

Acute empyema *can* be cured by aspiration and systemic and local antibiotic therapy but serious troubles will persist unless certain rules are observed scrupulously —

1 Aspiration must be resolute being carried out every other day with radiological and bacteriological control On each occasion, after the fluid has been removed 200 000–500 000 units of penicillin in 10 ml of saline solution are instilled into the pleural cavity In the event of the infection being caused by a penicillin resistant, but streptomycin-sensitive bacteria, 2 G of streptomycin in 10 ml. of saline solution can be substituted.

2. Aspiration must be abandoned in favour of operation as soon as attempts to aspirate the pus are persistently hampered by blockage of the needle by fibrin and thick pus. If masses of fibrin are left within the pleural cavity however good the general condition of the patient may be serious permanent damage to the lung and to chest wall function will almost certainly result

In infants and young children aspiration and antibiotic therapy is nearly always successful. This is fortunate because infants do badly with either rib resection or even intercostal drainage owing to the fact that localizing adhesions are so often conspicuous by their absence. Infection in children is usually staphylococcal and often accompanies staphylococcal pneumonia or lung abscess. If the infecting organisms are sensitive to the antibiotic used operation can be avoided (see LUNG ABSCESS, p 720)

THE OPERATIVE TREATMENT OF EMPYEMA

Since antibiotics have removed the major risk of empyema, rarely is there need to carry out intercostal drainage the indications for and the technique of which are described on p. 719

Indications.—In an adult with an empyema, operation should be carried out when (1) the pus becomes really thick and/or the aspirating needle becomes intermittently blocked with fibrin (2) when the clinical examination and radiograph show that localization has occurred. These indications are often present after three or four aspirations. It is important to stress once more that aspiration should not be repeated again and again in an attempt to evade operation, as patients so treated are liable to develop much pleural fibrosis, a chronic empyema, or a bronchopleural fistula.

Delineation of the Cavity with Lipiodol.—When operation is contemplated after aspiration 3 ml. of lipiodol is introduced into the cavity Subsequent X ray examination will delineate the lowest limit of the cavity and indicate the best site for drainage

Choice of Operation.—The operative procedures in use for empyema at the present time are —

1 Rib resection and drainage (open or closed).

2. A wide thoracotomy followed by lung decortication, similar to the operation described under the treatment of clotted hæmothorax (see p 729) This operation is increasing in popularity because it leads to rapid convalescence following full re-expansion of the lung

TECHNIQUE OF DRAINAGE BY RESECTION OF A RIB

Forty minutes before the commencement of the operation the patient should have a suitable dose of morphine

Position of the Patient.—Owing to the beneficial effects of aspiration and antibiotic therapy but few patients are in poor condition at the time of operation consequently most of them can be placed in the classical thoracotomy position and operated upon under endotracheal anæsthesia If, however sputum is present, local anæsthesia is preferable and the patient can be operated upon in a sitting posture, being well forward on pillows, or in the prone position as shown in *Fig* 980

Selection of the Rib to be Resected.—This depends entirely on the situation of the empyema, as determined by the pleurogram. In the commonest variety the angle of the scapula is palpated *with the arm by the side* (*Fig* 981) The rib immediately below this point is the most suitable for resection. If the rib *above* this point is selected, the scapula will

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act as a shutter and consequently impede drainage. If a rib *below* this point is chosen, the chances of inadvertently *performing a transthoracic laparotomy* are much greater than might be expected. One often hears that the lowest possible true rib should be chosen. This is bad teaching. Choosing the lowest possible true rib may endanger the

Fig. 980.—Empyema. Infiltrating the subcutaneous tissues with local anæsthetic.

diaphragm, incision of which has led to prolapse of omentum or intestine into the pleural cavity. Another objection is that after drainage the diaphragm rises invariably and this is liable to block the drainage tube. Therefore *choose not the lowest true rib but one just clear of the scapula.*

When all is in readiness for the operation, when the skin has been painted and towels are in position, *the selected rib is found by palpation, the arm, as just noted, being by the*

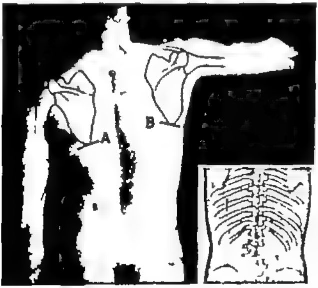


Fig. 981.—In selecting the rib most suitable for resection in the average empyema—i.e., that immediately below the angle of the scapula—the arm must be by the side (A). The level of the scapula when the arm is raised is shown at B. Inset shows a vertical incision in relation to the ribs.

patient's side. With the finger still marking this point the arm is held out of the way and there maintained throughout the operation.

Infiltration of Local Anæsthetic: Exposure of the Rib.—The skin over the rib is infiltrated with 1 per cent procaine for about 4 in. (10 cm.). The subcutaneous area is infiltrated widely (*Fig.* 980). One pauses for a few moments to massage the œdematous tissues with

a swab. The incision[1] is made and deepened bleeding points are ligated. The varying amount of muscle encountered is infiltrated and divided The periosteum is in view and it is infiltrated as far as possible The time is now ripe for the crucial point in anæsthetization—viz., the perineural injection of the intercostal nerve The needle is passed under the lower margin of the rib as far back as possible—i.e near the angle of the rib—so that its point lies in the intercostal groove (*Fig* 982). Of the structures

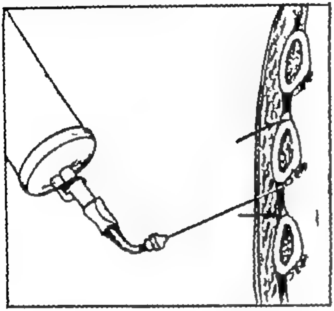


Fig. 982.—Infiltration of local anæsthetic prior to rib resection. The needle is passed into the intercostal space Note that the nerve is the lowermost structure in this space The subsidiary areas of infiltration referred to in the text are also shown, indicated by arrows.

Fig 983.—Elevating the periosteum from the superficial aspect of the rib

in the intercostal groove the nerve lies lowermost and so is within easy reach The anæsthetic fluid should be infiltrated slowly here. The periosteum is supplied largely from the intercostal nerves of the rib above and the rib below therefore secondary infiltrations are made about the lower edge of the rib above and the upper edge of the rib below

Resection of the Rib.—The whole length of the exposed periosteum is incised. Using an elevator (*Fig* 983), the periosteum is peeled off to the edges of the rib. Doyen's raspatory is introduced under the periosteum, and sweeping around the upper border of

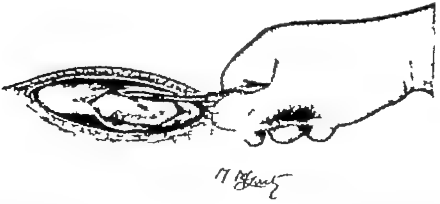


Fig. 984.—Doyen's raspatory is used to strip the periosteum from the deep aspect of the rib.

the rib, its beak is made to protrude subperiosteally at the rib's lower edge without damaging the rib-bed. By sliding the instrument to and fro the periosteum is stripped from the internal surface of the rib (*Fig* 984). The raspatory comes to rest at the anterior end of the rib and serves as a guide for the rib shears. Rib shears of the type illustrated

[1] Instead of the incision following the line of the rib as illustrated, a vertical incision through the soft parts is preferred by some operators.

(*Fig* 983) minimize wounding vessels and the pleura. The rib is resected within the limits of the incision. This is the only painful part of the operation. Some state that it is not pain that disturbs the patient but the sound of the section of the bone. In any case it is necessary to warn the patient to keep steady and this stage of the operation is carried out as expeditiously as possible

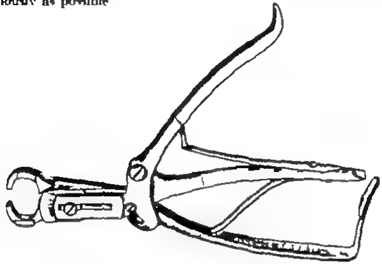


Fig. 983.—Vehmebren's costotome

Inspection of the Bed of the Rib: *Resection of the Intercostal Nerve.*—The portion of rib having been resected, its bed is examined firstly to make sure that there is no bleeding from the intercostal vessels and secondly to isolate the intercostal nerve. By blunt

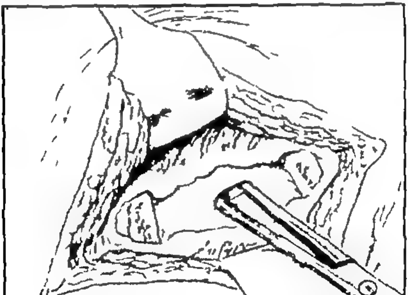


Fig 984.—Opening the pleura. A slight upward tilt is given to the forceps the better to avoid the diaphragm

dissection the intercostal nerve is separated from the vessels, and within the limits of the incision the nerve is resected. This small refinement is of great practical utility in the prevention of post-operative pain.

Before opening the pleura the cut ends of the ribs can with advantage, be smeared with Horsley's bone wax to help prevent infection.

Opening the Pleura.—The pus is sought once more with a wide-bore aspirating needle before a small incision followed by the introduction of sinus forceps (*Fig* 980) is made. Quickly a finger explores the interior Care must be taken to avoid abrading the finger on a protruding spicule of bone; severe infections of the hand have followed this accident. Full exploration of the cavity is important especial care being taken not to overlook a bilocular empyema

Emptying the Empyema.—All the fluid pus is removed by suction or if a suction apparatus is not available by rolling the patient nearly on to his back and collecting the escaping pus in a receptacle It is important to remove as much of the fibrin clot as possible, because this is a potent cause of persistent fistula. Fishing with the sucker and extracting clots which adhere to it, aided if necessary by a light touch with sponge-holding forceps and wiping around the walls with a swab on a holder are two valuable methods. If the patient is under general anæsthesia and the lung is bound down by a thick fibrin envelope the decision may be made to carry out *decortication of the lung* this, however should not be undertaken by an inexperienced surgeon. It should be followed always by closed drainage to encourage rapid re-expansion of the lung

Inserting a Drainage Tube.—

a Closed Drainage—If the cavity is a large one, closed drainage is advisable as the restoration of negative intrapleural pressure will encourage lung re-expansion and avoid the need for frequent changes of dressings. A tube of wide bore is selected. The external diameter should be about ¾ in. (18 mm.). The end is cut obliquely It is introduced so that it rests on the floor of the cavity with the oblique opening upwards. The following is a good method of ensuring a water tight closure A chromic catgut suture is placed through the internal periosteum and the pleura on each side of the tube, and tied to prevent enlargement of the opening Each pair of the long ends of these sutures is tied around the tube to hold it in place. The intercostal muscles, fascia, and skin are approximated with interrupted sutures so that they fit snugly around the tube The tube is then clipped with a hæmostat and dressings are applied. When the patient is back in bed the tube is connected to a water-sealed bottle (see p. 716)

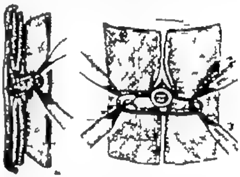


Fig 987—Arrangement of the tube and dressings in open drainage. The objective is to fix the tube securely without discomfort and without impeding drainage

b Open Drainage—Smaller empyema cavities can be drained safely by the open method, in which case the skin and underlying muscles are brought loosely together about the tube with through-and through sutures. The tube must always be fixed firmly by the method shown in *Fig* 987 The strips of narrow adhesive plaster adhere more firmly if the skin is painted previously with tinct. benzoini co

Empyema caused by Gas-forming Organisms.—Drainage of an empyema caused by virulent anaerobic organisms calls for important alterations in the technique of the final stages of the operation If as is often the case, closed drainage is highly desirable because the empyema is a large one, the internal periosteum and the pleura are closed about the tube in the manner just described, *but not a single suture is placed in the muscle or the skin* By leaving the superficial tissues unsutured the danger of spreading cellulitis is obviated This type of closed drainage will not remain air tight for more than about six days, but by the end of that time the entrance of air into the pleural cavity is of comparatively little importance

SOME COMPLICATIONS ARISING DURING AN OPERATION FOR EMPYEMA AND THEIR MANAGEMENT

Hæmorrhage from the Intercostal Artery—Bleeding coming from under the cover of the cut edge of the rib may be alarming It is usually futile to attempt direct ligation for the arterial wall is fragile and the artery itself most inaccessible *Resection of a further portion of rib* will enable good exposure to be obtained the neurovascular bundle can then be divided between two encircling sutures.

Now that larger segments of rib are usually excised in the operation of rib resection and drainage *this complication is rare* *secondary hæmorrhage from an intercostal vessel is* seen occasionally. It is presaged by steady oozing and clot formation around the tube. It must always be regarded seriously and the patient should be taken at once to the operating theatre where the wound is opened up widely, irrigated with warm saline solution and the vessel secured well away from the site of bleeding. The risk of this complication can be greatly minimized if the intercostal vessels are divided between suture-ligatures at the primary operation.

Transpleural Laparotomy has been Performed Inadvertently.—In most cases the opening into the pleura has been made too low. Pus has not been struck, for the empyema is an encapsulated one not extending into the lowest part of the pleural cavity, otherwise the accident is unlikely to have occurred. The very fact that pus has not been found leads the operator to think that the pleura is still unopened, and so, mistaking the diaphragm for thickened pleura, he plunges into the peritoneal cavity.

Once the mistake is recognized, precautions must be taken to ensure that the pus sac is not opened until the repair of the diaphragm has been effected. The protruding viscera are washed with warm saline solution, and returned to the abdomen. Deliberate closure of the diaphragm with interrupted sutures in two layers is effective. Now that adequate antibiotics are available, the risk of peritonitis is negligible. Wounds of the diaphragm are liable to be the site later of dangerous diaphragmatic hernia with strangulation of intestine, hence the need for a double-layer closure.

The Rib which has been resected is too High or too Low; it is thought that Drainage will be Inadequate.—Resect a second rib immediately adjacent. The anæsthesia, if local, must of course be supplemented, but the resection of a second rib does not take long.

The Pleura has been opened, but no Pus is found therein.—It goes without saying that the operation would not have been undertaken if the aspirating needle had not withdrawn pus. First of all explore with the finger. Possibly the empyema is a localized one and a loculus may be entered. After this has been done with a negative result, the possibility of a lung abscess or an interlobar abscess must be considered. *At this juncture on two occasions* I punctured the lung with an aspirating needle and found a large cavity, which was drained successfully.

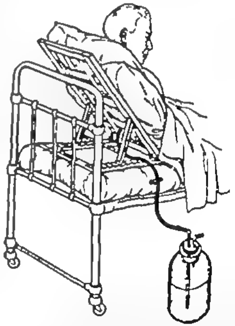


Fig. 989.—Showing the arrangement of the backrest and pillow for closed drainage. The tube should not hang in a loop between the safety-pin which fixes it to the mattress, and the bottle. The patient should sleep in this position.

ASSEMBLING A WATER-SEALED SYSTEM

When the patient is back in bed and has recovered sufficiently from the general anæsthetic, if one has been administered, the drainage tube is connected to a water-sealed bottle (*Fig.* 988) by means of a well-fitting glass connexion and a suitable length of sterilized rubber tubing; the hæmostat closing the drainage tube is then removed. If there is no leak between the empyema cavity and the bottle, the subatmospheric pressure in the pleural cavity causes the water to rise up the long glass tube. With each respiration this column of water oscillates; a violent cough will blow the water out of the tube and possibly cause bubbles of air to pass through the water before the column of water again ascends to its usual levels of oscillation. Pus descends into the bottle. The exit tube must be so arranged that it is not pressed upon or kinked (*Fig.* 989).

Fig. 988.—Water-sealed bottle.

Nursing Instructions.—

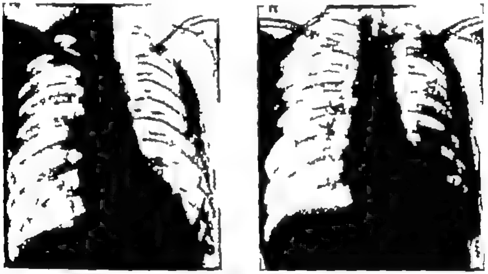
1 If the column of fluid ceases to move up and down with respiration report the matter

2. Clip the tubing with a hæmostat before emptying the bottle and changing the water each day Subtract the amount of water put into the bottle from the total emptied, and record the quantity of pus that has been discharged in 24 hours. Fill the bottle one third full after rinsing it. Reconnect the apparatus. Remove the hæmostat

3. On no account must the ward maid or anyone else remove the bottle from the floor If for instance during cleaning the ward the bottle is placed even for a few moments, upon a chair or table the fluid will be sucked into the patient's pleural cavity often with serious or even disastrous results.

THE POST OPERATIVE MANAGEMENT OF THE TUBE

Much misunderstanding still exists about the basic principles underlying the post operative management of the drainage tube by far the commonest cause of a chronic empyema is the inadequate drainage of the empyema that follows premature removal of the tube. The tube can only safely be shortened and eventually discarded when there is certain evidence that the lung has fully re-expanded to obliterate the space previously occupied by pus. *This rule must be observed.* By far the safest way of discovering the exact



A B

Fig 990.—A, Showing a barium-loaded tube in an apparently healed empyema track. B Sinogram showing the outline of an extensive residual cavity Removal of the tube at this stage would have resulted in chronic empyema

state of the cavity is to perform a sinogram this is easily done by taking radiographs in the anteroposterior and lateral planes after lipiodol has been run into the cavity (*Fig* 990) In the radiographs reproduced here, the straight radiograph gives a deceptive appearance of the size of the empyema cavity its real size has been delineated by the lipiodol. If as sometimes happens, a sinogram reveals that the cavity is tending to close from below a longer tube must be used to drain the cavity (*Fig* 991B) As the cavity continues to fill in from below a still longer tube must be employed (*Fig* 991C) until only a tube track remains, when the tube is shortened gradually In all cases the tube should only be discarded when the sinogram shows that only a short tube track remains.

If closed drainage is in use, constant watch must be maintained to ensure adequate constant drainage if a column of water does not move up and down in the hollow glass tube leading down into the water-sealed bottle something is amiss. The tube should be forcibly milked to restore patency if this fails, the tube must be removed and replaced with another one as it will be found to be blocked by fibrin. Irrigation is not advised, as it may cause serious complications such as fistula and air embolism. The drainage of pus and lung re-expansion can be accelerated by the use of Roberts's suction motor if one is available

When the radiographs show the lung to be well expanded, the closed system can be abandoned *for open drainage* which frees the patient for more activity than is possible when he is tethered to a water sealed bottle

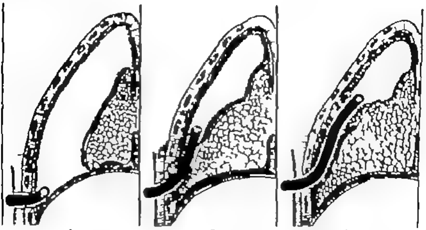


Fig. 991.—Illustrating closure of an empyema, from below upwards. In such cases the tube must be lengthened repeatedly till only a track remains, when it is shortened gradually

The Use of Breathing Exercises.—From the first post-operative day the patients should be encouraged to maintain a good position in bed and to practise deep-breathing exercises; the services of a physiotherapist are invaluable as many patients do not carry out these exercises well until they have been taught to do them properly. Chest wall and diaphragmatic movements often against light pressure (*Fig. 992*) are of great value. Such exercises

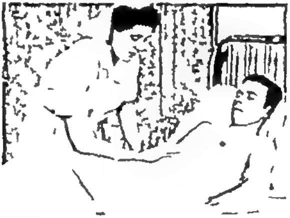


Fig. 992.—Patient performing breathing exercises under physiotherapeutic control.

have completely replaced forced blowing up of balloons, etc. which result in poorly co-ordinated, exhausting efforts.

Diet.—*As these patients lose much protein, a diet rich in this must be given;* the general health of the patient calls for the usual methods of support, e.g., fresh air, early movements, and iron by mouth.

EMPYEMA FOLLOWING MAJOR THORACIC OPERATIONS

Infected effusions following lobectomy or excision of a lung are usually due to a bronchial fistula; their treatment follows the practice described elsewhere but adequate drainage is often required. Should an infected effusion develop after œsophagectomy leakage from the anastomosis must be suspected; such a catastrophe usually requires re-opening of the thoracotomy wound and repair of the leaking anastomosis.

THE CLOSED METHOD OF INTERCOSTAL DRAINAGE

The closed method of intercostal drainage is required occasionally in young children, when the pus becomes too thick to aspirate. In early life intercostal drainage is preferable to rib resection. In older children and adults this method should be confined to desperately urgent cases where the patient is too ill to be moved and drainage has to be effected as he lies in bed. Such cases are rare because a patient who is too ill to be moved should as a rule be treated by aspiration and antibiotic therapy. Another indication for intercostal drainage is for the treatment of infected effusions following intrathoracic operations in the hope that rapid lung re-expansion will follow. If this does not occur adequate drainage after rib resection is called for.

Fig. 993.—Apparatus assembled for intercostal drainage.

As before, the *time* at which the operation is performed is of fundamental importance. From the Children's Hospital, Winnipeg, comes the following excellent aphorism: "When the organism present is a pneumococcus *thick* pus must be present for a week before drainage is undertaken; when the organism is the streptococcus *thick* pus must be present for at least ten days." (J. D. McEachern.)

As pointed out by d'Abreu, intercostal drainage can be carried out expeditiously with the bladder perforator described on page 643. The sterilized perforator, a No. 28 reinforced Malecot catheter, and the necessary tubing are connected to a water-sealed bottle (*Fig.* 993). These preliminaries prevent air entering the pleural cavity during and after the operation. The apparatus should be assembled before the operation is commenced.

Technique.—The skin is infiltrated with procaine solution (under the age of 3 years a 0·5 per cent solution is sufficient). The needle is advanced slowly towards the pleura and more of the anæsthetic solution is injected into the muscle planes. Eventually the pleura

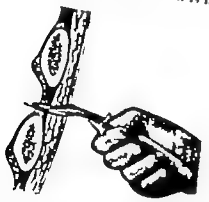


Fig. 994.—Bladder perforator being employed to introduce a No. 28 reinforced Malecot catheter evenly coated with petroleum jelly between the ribs.

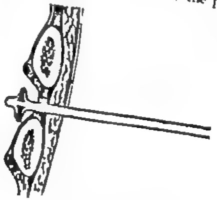


Fig. 995.—Intercostal drainage completed.

itself is infiltrated, and the needle pushed on into the effusion. The plunger is withdrawn: pus wells into the barrel of the syringe.

Having made a tiny incision, the catheter (lightly coated with petroleum jelly) is stretched on the perforator and with a short sharp stab the pleura is entered between the ribs (*Fig.* 994). To have the catheter lubricated greatly facilitates its passage through the chest wall. When the perforator is withdrawn, the flanges of the catheter expand and fit snugly against the parietal pleura (*Fig.* 995). Pus flows into the bottle and with each respiratory excursion negative pressure in the pleural cavity is demonstrated by the rise and fall of fluid in the long glass tube.

Sealing the Incision. McEachern's Technique.—Successive layers of cotton-wool, 5 in. (12·5 cm.) in diameter and soaked in collodion, are built up about the tube to the depth of half an inch. In order that this dressing may adhere firmly, the skin and the adjacent catheter are swabbed with

ether. Mastisol is applied to the skin with a brush. A thin layer of cotton-wool is laid on and smoothed out with the brush. More collodion is applied. Successive layers of cotton-wool are superimposed in a similar manner until the dressing is of the required thickness. The dressing will remain tight longer if the catheter is incorporated in the following manner: when the dressing is about half applied a small round needle threaded with a double strand of thread is passed through the wall of the catheter without entering its lumen. The double end is cut. Similarly another thread is passed through the opposite wall of the catheter. These four threads are embedded in the dressing. The dressing is fanned for twenty minutes before the patient is moved from the operating table.

ABSCESS OF THE LUNG

A complete change has taken place in the management of lung abscess: what used to be a rather common disease with a mortality of over 30 per cent has now become unusual and rarely causes death. Most lung abscesses are due to carcinoma of the lung or follow aspiration of infected material into the tracheobronchial tree, e.g., vomit, septic material from the teeth, mouth, upper respiratory passages, foreign bodies. Such are therefore

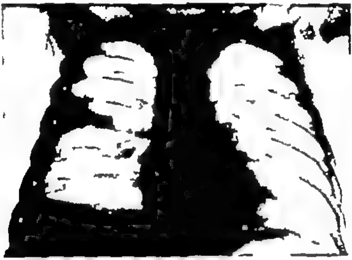


Fig. 990.—Radiograph of a child with a staphylococcal abscess of right upper lobe. This resolved completely with prolonged penicillin therapy.

preventable. In infants and children the commonest cause of lung abscess is that following staphylococcal pneumonia (*Fig. 990*).

The standard treatment to-day is based on antibiotic therapy employed daily for six weeks if penicillin is effective, for shorter periods if the broader spectrum antibiotics are used. Postural drainage is employed as an auxiliary. Drainage of lung abscess is almost an obsolete operation. When operation is required it usually demands lobectomy for a cavitated lobe that is the cause of a persistent production of sputum.

ACUTE MEDIASTINITIS AND MEDIASTINAL ABSCESS

Cases of infection of the mediastinum are encountered but rarely; the more common causes are perforation by a sharp-pointed foreign body impacted in the œsophagus (see p. 741), operation involving the mediastinum, acute rupture of the œsophagus (see p. 74[illegible]), and tuberculous disease of the spine.

As a rule tuberculous paravertebral abscess is not an emergency, and it responds to immobilization, streptomycin and chemotherapy; exceptionally the abscess ruptures into the pleura, or presents in the suprasternal notch or between two ribs. Aspiration should be practised unless paraplegic symptoms develop in spite of strict immobilization. Such a combination of complications calls for expert orthopædic surgery, which comprises decompression of the affected spinal nerve and bone-grafting of the spine. I have seen dysphagia and stridor develop as a result of a tuberculous mediastinal abscess; gastrostomy, a steam tent, and streptomycin relieved the state.

Acute Mediastinitis following Perforation of the Œsophagus.—*See* p. 74[illegible]

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Revised by A. L. d'Abreu, O.B.E., Ch.M. (Birm.), F.R.C.S. (Eng.)
Surgeon, Birmingham United Hospitals
Adviser in Thoracic Surgery, Birmingham Regional Hospital Board

CHAPTER LXIII

THORACIC INJURIES

INJURIES of the thorax are either open or closed. In civilian practice crush injuries of the chest due to motor-car or aeroplane accidents are encountered frequently. Gunshot and stab wounds provide most of the open wounds.

In both types of injury surgical treatment is staged as follows:—

A. The Immediate Phase.—Life-saving measures are devoted to the rapid restoration of respiratory function, e.g. the re-adjustment of altered intrapleural mechanisms, the prevention of paradoxical breathing, the clearing of the air passages, the relief of anoxia by oxygen therapy, and of anæmia by blood transfusion. Measures that may be required include aspiration of air and blood from the pleural cavity, continuous intercostal drainage for persistent air leaks from the lung, the application of firm elastic pressure to stop paradoxical chest wall movements in cases of multiple rib fractures, the encouragement of coughing which, if ineffectual, may require assistance by bronchoscopic suction or tracheostomy.

B. The Second Phase, which is concerned with the Restoration of Function and the Prevention or Treatment of Infection.—During this phase, major operative intervention, antibiotic therapy, and physiotherapy all play important roles.

GENERAL ASSESSMENT OF A THORACIC INJURY

On admission, the patient with a thoracic injury, closed or open, should be subjected to a routine assessment. Clinical and radiological examinations (the latter should never be omitted) can answer all the following questions:—

a. Is the injury entirely thoracic? Is there a concomitant abdominal injury, e.g., rupture of the liver or spleen? (*see* Chapter XXXIV). A purely thoracic injury can so irritate the intercostal nerves as to mimic an abdominal injury by the production of upper abdominal rigidity.

b. Is the spine injured?

c. Is there a hæmothorax or a pneumothorax present? This question is answered by clinical and radiological examinations and confirmed by needle aspiration.

d. Is there atelectasis of a lung or a lobe as the result of mucopus or blood in the bronchi? Such a condition may necessitate bronchoscopic aspiration if the patient's coughing efforts, actively encouraged, are ineffective.

e. Is there a foreign body present?

f. Is there a cardiac or pericardial injury? (*See* p. 732.)

g. Is cyanosis present? If so, after it has been ascertained that there is no obstruction to the upper air-passages, oxygen therapy is indicated.

h. Is the patient anæmic? This is assessed clinically and by hæmoglobin estimations. Treatment is chiefly by blood transfusion.

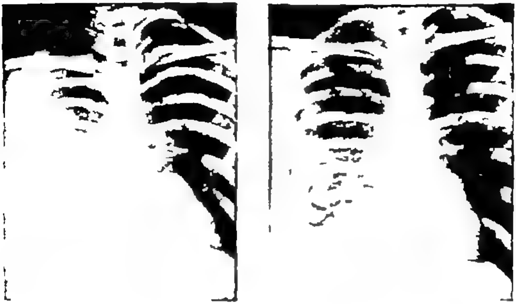
In conclusion, it is important to stress the fact that a large hæmothorax can exist with surprisingly unimportant clinical signs; to confirm or disprove the presence of a hæmothorax rely on radiography and needle aspiration. The commonest error in the management of thoracic injury is to overlook a hæmothorax.

COMPRESSION INJURIES WITH OR WITHOUT FRACTURES OF RIB

Hæmothorax and Hæmopneumothorax are the commonest complications of a compression injury with fracture of a rib or ribs. The onset is sometimes insidious, and in all relevant cases it should be looked for over a period of a few days, even after the fracture of a single rib. Reliable signs for its detection are the presence of dullness on percussion, absent breath-sounds, and typical radiological appearances (*Fig.* 997).

Treatment.—The current practice is to aspirate the chest within twelve hours of the injury to relieve pressure, encourage rapid lung re-expansion, and to remove a fluid medium

suitable for bacterial growth. If the hæmothorax clots, rendering aspiration impossible, or becomes infected, thoracotomy is indicated. Thoracotomy for hæmothorax is described on p. 729.



A B

Fig. 997.—Radiographs of chest, showing right hæmothorax. A, Before aspiration; B, After one aspiration. Note appearance suggestive of diaphragmatic hernia due to fibrin masses and air pockets in B. (*A. Tudor Edwards.*)

Paradoxical Respiration follows severe multiple rib fractures in which several ribs are broken, both anteriorly and posteriorly, so as to render a segment of thoracic wall "floating" (flail chest). This segment is sucked in during inspiration and driven out during expiration; the breathing is therefore paradoxical, one side of the chest moving in while the other moves

Fig. 998.—A patient with severe head injuries and multiple fractures of the ribs of the left side, paradoxical breathing, and atelectasis of lung. A tracheostomy has been performed, and the ribs are steadied by wires enclosed in polythene tubes. To the enclosed wires is attached a cord that passes over a pulley, and to the end of the cord a 5 lb. (2·20 kg.) weight is attached. The polythene tubes prevent the wires cutting into the bone.

out. Such a mechanism behaves much like an open pneumothorax, so that carbon dioxide is drawn from one side of the affected lung to the other instead of being exhaled; dyspnœa and cyanosis inevitably follow. The paradoxus is corrected by strapping the injured side of the thorax firmly with flexible adhesive strapping, by judicious doses of morphine, and the administration of oxygen by a well-fitting oronasal mask or an intranasal catheter.

In these patients cough may be difficult or impossible and the accumulation of mucopurulent secretion is liable to produce collapse of the lung or a lobe such a condition requires intratracheal or bronchoscopic aspiration. If this does not provide rapid relief there is no doubt that *tracheostomy* often proves life-saving Tracheostomy provides relief from exhausting cough, and through the tracheostomy tube frequent suction of retained secretions can be performed at the bedside easily In bilateral multiple rib fractures, tracheostomy is always indicated. In addition, fixation of the floating segment may be required (*Fig* 098).

Fig 090 —Traumatic asphyxia.

Atelectasis.—Collapse of one or more lobes is not infrequent. Its treatment must be energetic (1) By physiotherapy and encouragement of the cough reflex (2) Transnasal endotracheal catheter suction after local anæsthetization of the larynx has been carried out by decicain or xylocaine (3) Bronchoscopic suction; (4) The use of antibiotics; (5) Oxygen therapy if cyanosis exists.

Traumatic Asphyxia follows compression of the chest, blood being forced from the intrathoracic veins into those of the head, neck and arms. Intense venous congestion and petechial hæmorrhages follow The appearances are remarkable (*Fig* 090). Retinal hæmorrhage and optic atrophy may follow unconsciousness sometimes develops. It is treated by maintaining a propped up position and giving oxygen.

Surgical Emphysema is a common complication of fractured ribs and thoracotomy. It produces a crepitant swelling beneath the skin and muscles (*Fig* 1000). It usually subsides without producing anything more serious than discomfort. Its treatment is that of the underlying cause, e.g., a lung leak which may require under water sealed drainage through a hollow needle leading to a bottle (*Fig* 1001). The emphysema usually subsides in a few days. In itself it does not threaten life.

Fig. 1000.—Widespread surgical emphysema following fractured ribs in a female aged 62. (*S. Mercer.*)

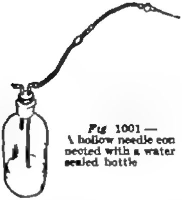


Fig 1001.—A hollow needle connected with a water sealed bottle.

Mediastinal Emphysema is a condition associated with a constant escape of air into the mediastinum, such as may occur in wounds of the trachea, bronchi or even the œsophagus. In severe cases the neck and face become suffused and livid (*Fig* 1002), the lividity arising from pressure on the great veins at the root of the neck. The condition threatens life and calls for prompt treatment.

In severe cases cardiac embarrassment must be relieved at once. Make an incision in front of the infrathyroid portion of the trachea. Ligating vessels as they are encountered, deepen the incision right down to the trachea. Improvise some form

Fig 1002.—Mediastinal emphysema.

Fig 1003.—Mediastinal emphysema after treatment.

(*Max Thorek.* *By kind permission of Messrs. Saunders.*)

of suction to the wound (*Fig* 1003). By this means the air can be withdrawn gradually and usually relief follows. When the escape of air is from the upper part of the trachea, tracheostomy is indicated and this will prevent further leakage into the tissues. Bronchial (*see* TORN BRONCHUS *below*) and œsophageal (*see* pp. 742, 830) tears can be diagnosed.

Tension (syn. Valvular) Pneumothorax.—Under this heading fall cases in which some blood as well as air is extravasated into the pleural cavity but the air decidedly predominates. The cause is a laceration of the lung communicating with a branch of the bronchial tree. This permits air to enter the pleural cavity from the lung during inspiration, but it does not permit it to escape during expiration—hence the term valvular.

Increasing dyspnœa and cyanosis are the leading symptoms. Absence of breath-sounds, hyper-resonance, cardiac displacement, pallor and a poor pulse are classical signs.

As the air accumulates in the pleural cavity, so the mediastinum and trachea tend to become more and more displaced (*Figs* 1004, 1005).

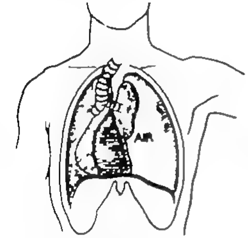


Fig 1004.—Tension (valvular) pneumothorax. Showing displacement of mediastinum and trachea. (*After J. I. Dobrer.*)

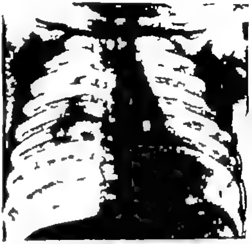


Fig 1005.—I. T., aged 4. Right pneumothorax following a kick in the chest.

Treatment.—The condition may become urgent. The introduction of a trocar and cannula between the ribs, allowing the entrapped air to escape, is indicated in a real emergency. This should be followed, as soon as possible, by the insertion of a catheter connected to a water-sealed bottle.

For cases not so urgent, the introduction of a wide-bore hollow needle is recommended. The optimum site for the puncture is the second intercostal space, 2 in. (5 cm.) from the edge of the sternum.

The track of the proposed puncture is infiltrated with 1 per cent procaine and the aspirating needle is thrust into the pleural cavity. When air ceases to escape the needle is withdrawn and the puncture sealed.

When air re-accumulates the re-inserted hollow needle can be left in position, and connected with a water-sealed bottle containing antiseptic solution. The bottle must be placed below the level of the bed, i.e., on the floor (*Fig* 1001).

It is impossible to fix the needle properly for any length of time; amongst other difficulties these dyspnoeic patients are restless. To introduce a No. 28 Malecot catheter by means

HÆMOTHORAX

Hæmothorax or hæmopneumothorax is the most important complication of thoracic injury requiring active treatment. In 1000 consecutive chest injuries (wounds and crushes) treated in Italy 830 had a hæmothorax (A. L. d'Abreu)

Collections of blood and air in the pleural cavity embarrass breathing produce a pyrexia even when uninfected and are notoriously liable to become infected If not removed,

Fig. 1006.—The best site for designed thoracotomy is over the 8th or th rib as shown.

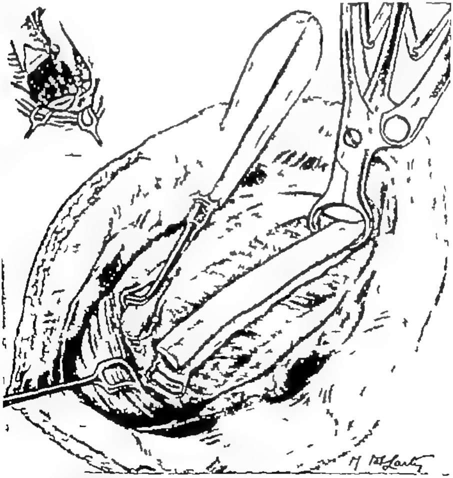


Fig. 1007 —Thoracotomy by wide excision of one rib, and resection of 1 in. (2·5 *cm.*) of the super-adjacent rib behind its angle after displacement backwards of the spinalis thoracis. Inset shows division between ligatures of the intercostal vessels. The pleura is opened by incising the bed of the resected rib.

Management.—Undoubtedly the ideal treatment is adequate early aspiration. Aspiration will not restart bleeding from the lung because indubitably most of the blood comes from the chest wall and not from the lung unless a large vessel in the latter has been damaged, in which event the bleeding is so severe that death supervenes rapidly unless thoracotomy can be performed almost immediately. Since the aim is to produce rapid re-expansion of the lung aspiration with air replacement should *not* be performed. This lesson was well learnt in the Second World War.

Method.—After the injection of local anæsthetic (*see* p. 71–) a large-bore needle attached to a two-way tap or a Potain's apparatus is inserted into the pleural cavity and the hæmothorax aspirated as completely as possible. At the conclusion 1 000 000 units of penicillin are instilled into the pleural cavity. The removed fluid is sent for bacteriological examination.

The aspiration should be repeated *daily* until radiographs show an absence of fluid in the pleural cavity.

Indications for Thoracotomy.—Two indications exist. (*a*) In the early phase if continued bleeding is taking place as determined by the signs of grave internal hæmorrhage or the refilling of the pleural cavity with blood almost as soon as it has been aspirated; this type of case occurs infrequently. (*b*) If a large hæmothorax exists and cannot be aspirated because of the constant blockage of the needle by fibrin clots; infection of the hæmothorax is often present in these cases.

Operation.—Under endotracheal anæsthesia through the incision shown in *Fig.* 1006 the chest is opened widely by thoracotomy after resection of a large segment of a rib and a small segment of a rib immediately adjacent (*Fig.* 1007). Fibrin and blood-stained effusions are removed by mop and sucker; a dense envelope covers the lung which is motionless, even when the anæsthetist tries to inflate the lung. This envelope is removed (*Figs.* 1008–1010) and the strangled lung soon re-expands. The chest is closed in layers with drainage connected to a water-sealed bottle. Drainage is maintained until radiographs show the lung to be expanded fully.

TRAUMATIC CHYLOTHORAX

Following an injury to the thorax, usually with a fracture of a rib or ribs, signs of hydrothorax develop and a radiograph reveals opacity over the entire field of the right lung. This rare injury is more likely to occur after a large meal when the duct is distended with chyle. In addition to laceration by a fractured rib, this accident has occurred after a stab or a gunshot wound, lysis of pleural adhesions, pneumonectomy, extrapleural pneumothorax, and (chyloperitoneum) after lumbar sympathectomy.

Aspiration reveals typical chyle. Aspiration 3–6 hours after the ingestion of a feed containing a considerable quantity of cream, coloured green or purple with a fat soluble dye used in confectionery will materially aid in confirming the diagnosis, but it should be noted that the aspirated chyle may be uncoloured until it is stirred with a rod. Stirring causes a curd to form which adheres to the rod and, strangely, it is the curd that takes on the dye, which sometimes is not visible in the gross specimen.

Repeated aspiration, a restricted fluid intake, a fat free diet rich in protein, the administration of plasma, and blood transfusion or gravitating the aspirated chyle into a vein will help to maintain nutrition. Even so, a patient not absorbing chyle wastes rapidly. While with this régime a number of patients have recovered, if there is not a considerable reduction in the outpouring of chyle after 7 days operation is recommended, otherwise the patient will lapse into such poor condition that he will be unable to withstand thoracotomy. It is difficult to understand the reluctance with which elective ligation of the thoracic duct has been received, especially as without operation the mortality among these patients is high.

Operation.—Between 3 and 6 hours after a feed of coloured cream in order to aid in identification of the torn thoracic duct, a rather low right-sided thoracotomy is performed. The intrathoracic course of the thoracic duct is along the bodies of the vertebræ between the aorta and the azygos vein. At the level of the 5th dorsal vertebra the duct crosses the middle line to pass behind the arch of the aorta, to empty into the left subclavian vein near its junction with the internal jugular vein. The torn duct having been identified its proximal end is ligated and the thorax is closed with water sealed drainage.

Throughout its length there are numerous connexions of the thoracic duct with the venous system consequently if operation is not delayed until the torn duct is sodden and friable ligation is attended with a rapid and permanent cure in nearly all cases where it has been carried out

FRACTURE OF THE STERNUM

Fracture of the sternum is a rare injury usually following direct violence e.g., from the steering wheel of a motor-car It occurs most often near the junction of the body of the sternum with the manubrium Pain is severe, and may interfere with respiration.

Treatment is by recumbency for ten days, unless this interferes with respiration in patients requiring an orthopnœic position. Gross over riding of a transverse fracture *especially if seriously interfering with breathing calls for early operative reduction and fixation.* Under endotracheal anæsthesia the depressed fragment is levered into position silver wire can be passed through holes made preferably by Brock's rib drill (*Fig* 1011), and twisted firmly enough to fix the fragments. Interrupted sutures through the periosteum and overlying soft tissue further help to steady the fracture. Union is rapid.

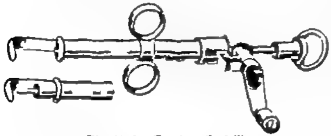


Fig 1011 —Brock rib drill.

Flail Sternum.—Instability of the thoracic parietes due to a flail sternum is a grave injury typically it is due to a steering wheel accident. Coughing is mechanically impossible bronchial secretions are retained, pain is severe, and œdema of the lungs ensues.

First-aid treatment is to give oxygen, if possible with a closed-system nebulizer to *prevent foam formation (see p. 148)* *The sternum should be anchored by the application* of traction applied with an ice-tong calliper Sufficient weight to prevent the sternum being sucked in during inspiration applied over a pulley is the only means of preserving life Operative fixation of the sternum should follow in necessary cases.

OPEN WOUNDS OF THE THORAX

Open wounds of the thorax can be divided into two great classes—sucking and non sucking Sucking wounds are of the greatest urgency whatever the circumstances the wound must be closed temporarily there and then either by a firm pad or temporary suture If dyspnœa persists, air and blood are aspirated, a sedative given and oxygen is administered These are but temporary expedients which serve until the patient's condition has improved sufficiently to remove him to the operating theatre

Operative Treatment.—If it is possible, operation should be undertaken within six hours of the time of the injury and under penicillin protection. Under endotracheal anæsthesia, the wound is excised, including removal of broken fragments of rib and trimming the edges of the pleural membrane If the patient's condition is poor only the most rapid examination of the pleural cavity and lung is permissible through a *limited thoracotomy* This inspection is to ensure that no serious bleeding or major intrathoracic wound exists. After a small rib retractor has been inserted, blood is sucked out of the pleural cavity Usually if a laceration of the lung is present it will be seen to have stopped bleeding Since gas-gangrene of the lung is almost unknown, excision of a wound of the lung is not required but *in the case of a gunshot wound, if the condition of the patient permits, a search must* be made with a view to removing pieces of clothing which are not infrequently driven into the lung After having removed obvious foreign bodies, the wound of the lung can be repaired by inserting a few fine catgut sutures. The chest is closed in layers without any attempt being made to suture the pleural membrane The aim is to close the sucking wound. Temporary intercostal drainage to a water-sealed drainage system (see p. 716) is instituted

The post-operative course is governed by the radiological appearances persistent effusions are aspirated and if the lung is collapsed in part or whole coughing is encouraged but should this prove ineffectual, it is supplemented by bronchoscopic aspiration of the tracheobronchial tree

If the patient's condition is good the thoracotomy is more formal and foreign bodies (e.g., a bullet) can be palpated easily and removed When the patient's general condition gives rise to anxiety the removal of foreign bodies should be postponed to a later date

THORACO-ABDOMINAL INJURIES

Crush, stab and bullet wounds of the thorax can involve the abdominal viscera e g spleen, liver stomach, or intestine The diagnosis and treatment of these conditions are described in Chapter XXXV If their possibility is borne in mind the diagnosis will usually be made. It is important to remember that in the early hours of wounding of the abdominal viscera mentioned signs of shock may be absent. This is particularly so in the case of rupture of the spleen (delayed rupture) and every surgeon of experience knows of patients who have been sent to him with the lower ribs strapped and who later have become seriously ill as the result of a hitherto unsuspected rupture of the spleen.

Operative Treatment of Thoraco-abdominal Wounds.—In war many wounds of the trunk are of the through-and through type ; careful contemplation on the path of the missile will enable the surgeon to envisage the viscera likely to have been penetrated. It is true that the damage sustained in the abdominal portion of a thoraco-abdominal wound is usually the more impelling from the standpoint of immediate operation, and on this account the surgeon with little thoracic experience sometimes feels justified in exploring the abdomen only None the less, thoraco-laparotomy is the operation of choice for not only can the wounds of the thoracic wall and the diaphragm be excised during the golden period if as is usual, the patient is admitted within a few hours of wounding but oft times it is problematical if the patient could survive without the opportunity to repair intrathoracic, as well as intra abdominal, damage Finally the approach affords the exposure necessary to repair the diaphragmatic wound in two layers, without which a diaphragmatic hernia is almost certain to result.

The thoraco-abdominal incision is described on p. 308

Ruptured Diaphragm (*see* p 434)

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Revised by A. L. d'ABREU O.B.E., Ch.M (Birm.), F.R.C.S. (Eng)
Surgeon Birmingham United Hospitals
Adviser in Thoracic Surgery Birmingham Regional Hospital Board.

CHAPTER LXII

THE HEART

WOUNDS OF THE HEART

WHILE the majority of wounds of the heart prove fatal before surgical aid can be reached, the heart is not the fragile organ it was once supposed to be If the patient lives to be transported to a surgical centre suture of the cardiac wound offers a very fair prospect of a successful issue Of 132 cases of operation for injury to the heart and pericardium, 48 died and 104 recovered (Sir Charles Ballance).

Thanks to the antibiotics, suppurative pericarditis (due usually to organisms introduced at the time of wounding) is to a large extent preventable until comparatively recently *it was more to be feared than the shock of exposing and suturing the heart*

The ventricle is more frequently wounded than the auricle

Heart tamponade (*Fig* 1012) implies a muffling and compression of the heart coupled with a rising venous pressure and a falling arterial and pulse pressure produced by the increasing hæmopericardium. If the wound is small, heart tamponade may take hours to produce its lethal effect hence prompt recognition is of prime importance. In the case of penetrating wounds, the possibility of tamponade is not likely to be overlooked. With non-penetrating injuries, such as follow the impact of the steering wheel against the driver's chest in motor accidents, the clinician must be particularly alert to the likelihood of tamponade. In such circumstances, and with perhaps little or no evidence of external trauma, a myocardial laceration (which could be readily sutured) can give rise to a progressive and fatal compression beneath an unyielding pericardium In these instances, the indication for operation can be most urgent. Even in moribund patients the heart sometimes begins to beat vigorously when the pericardium is incised. *Aspiration of the pericardium in heart tamponade* (which should be performed as described on p 780) is often valuable as a temporary measure and in extenuating circumstances it can be repeated.

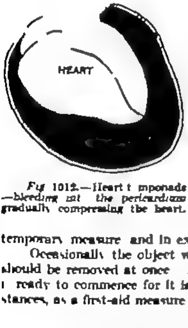

Fig 1012.—Heart tamponade—*bleeding int the pericardium* gradually compressing the heart.

Occasionally the object which caused the wound is still in situ. A protruding needle should be removed at once A dagger or knife must not be taken out until the operation is ready to commence for it is likely to be followed by gushes of blood. In other circumstances, as a first-aid measure the bleeding wound is plugged with dry gauze

EXPOSURE OF THE HEART

Special Instruments and Apparatus which are Advantageous.—

1 A *In all thoracic operations, if intratracheal anæsthesia is* available so much the better

2. A cotton glove for the left hand, to be worn over the rubber glove is helpful when holding the heart during the stage of palming (A. Lilienthal).

3. A strong mechanical retractor is desirable Tudor Edwards's is an excellent pattern. If no mechanical rib spreader is available a third assistant is essential

4 Six curved needles carrying tested ligatures are laid in readiness on the instrument table before the operation is begun.

5. Rib shears and nibbling forceps (for sternum) should be at hand but are seldom necessary

Special Preparations.—

1 Arrangements are immediately made to have the patient's blood *matched for transfusion* at least three pint (1 7 l) are ordered to be in readiness and whenever possible the transfusion should be proceeding before the operation commences.

2. If feasible a direct X-ray examination should be performed with the portable apparatus. This is particularly useful in showing the size and mobility of the heart and the presence of opaque foreign bodies. Radiological evidence of associated injuries may also be forthcoming, such as fractures of the thoracic cage or a hæmopneumothorax.

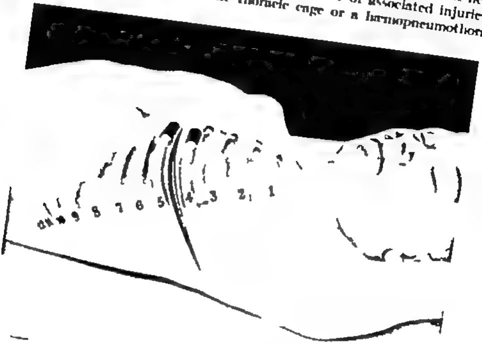

Fig. 1013.—Spangaro's incision. Classically the incision lies in the interspace between the fourth and fifth ribs, the costal cartilages of which are divided.

Spangaro's method of exposure (*Fig.* 1013) offers advantages, chief of which are the speed at which it may be performed and the fine exposure obtained. This incision allows a concomitant wound of the lung or hæmorrhage from the heart into the pleura to be dealt with.

Operation.—The wound is excised. This will lead to an intercostal space or less frequently to a rib overlying the heart. The incision is prolonged so as to resemble that shown in *Fig.* 1013. The intercostal muscles should be divided freely in the length of the incision. The costal cartilages above and below the interspace are isolated and divided near the sternum. If more room is required, further costal cartilages are divided. If a rib is found to be fractured, it should be removed. The mechanical retractor is introduced and the pericardium is in full view. The wound in the pericardium is enlarged with scissors. Instantly the left hand darts in to compress the beating heart.


Figs. 1014, 1015.—'Palming' the heart, sometimes known as the 'Sauerbruch grip'.

Depending upon the circumstances, one of three methods must be employed in order that the cardiac wound may be brought into view and repaired.

Palming the Heart.—The ring and little fingers are behind the ventricles (*Fig* 1014). The thumb and index finger remain free to compress the edges of the wound (*Fig* 1015).

Fig 1016.—Dislocating the heart. If the suture is not placed deeply it will surely cut out.

Elkin's Manœuvre, which consists of placing a finger in the hole in the heart, can be employed due care is taken to see that the rent is not enlarged by the finger Although this method has been disparaged, several surgeons have found it of practical value, and have brought their cases to a successful conclusion.

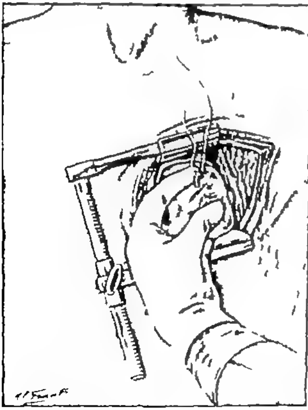

Fig 1017.—Suturing a wound of the heart.

The Apex Suture.—When the wound is situated on the posterior surface of the heart, the organ must be dislocated. A deep rather thick, silk suture is passed through the apex and the heart is gently delivered from the pericardium (*Fig* 1016) while an assistant maintains steady traction on the suture.

The wound in the heart is now closed with sutures after removing any obvious foreign material. If a finger is in the hole, one stitch is placed deeply as near as possible to the finger which is then removed. The remaining stitches can then be inserted easily and tied not too tightly by the surgeon himself. If the Sauerbruch grip is employed, the sutures are inserted as shown in *Fig* 1017 but they must be tied by the assistant. Mattress sutures are preferable when the muscle is unusually friable; this holds true especially for the auricle. When the cardiac wound has been closed securely the heart is allowed to fall back into place.

At this juncture occasionally the heart stops beating, in which event cardiac massage commenced at once is likely to prove successful More serious is the supervention of ventricular fibrillation for the treatment of which see p. 00

As pointed out by T Schrire external drainage of the pericardium invites ascending infection. Moreover in the rare event of the left pleura having escaped penetration by

the wounding, it is nearly always opened in order to get sufficient exposure for the operation. His advice, therefore is to suture the pericardium very incompletely i.e. by two or three interrupted sutures. This allows the pericardium to drain into the pleura thus avoiding the real danger of post-operative tamponade the pleura is drained with a large self retaining catheter passed through an intercostal space as in intercostal drainage of an empyema (see p. 719). The thorax is closed quickly by bringing the ribs on either side of the intercostal incision together by deeply placed encircling sutures. The skin is then sutured.

Before the patient leaves the theatre the circulation must be replenished with plasma or dextran, if the blood transfusion is not in progress already As soon as the patient is back in bed, the catheter draining the pleura is connected to a water-sealed bottle. Convalescence is usually stormy minute emboli may be thrown off from the sutured wound and lodge in the lungs. Pneumonitis a common complication, is combated by antibiotic therapy In order to minimize the occurrence of emboli some recommend that the suture material should be of paraffin-coated silk.

C. H Peck s Case.—

A girl aged 21 was brought to the Roosevelt Hospital in an ambulance, having been stabbed in the chest with a pocket knife half an hour before. There was no radial pulse but a weak pulse could be felt in the carotids. The heart-sounds could not be heard. The area of cardiac dullness was increased. There was a stab wound at the left border of the sternum over the third costal cartilage with very little external hemorrhage The patient was taken at once to the operating theatre. The pericardium was exposed and opened, and about 300 ml. of dark blood escaped with a gush. The degree of heart tamponade had been extreme, but directly the tension was released the anæsthetist reported a great improvement in the pulse The bleeding seemed to come from the upper right portion of the pericardial sac, but the rapidly beating heart churning the free blood made it impossible to locate the wound until a transverse cut into the pericardium to the right gave better exposure then by lifting the heart forward with the left hand and rotating it slightly to the left a wound of the right auricle was brought into view With each systole a stream of dark blood spouted two or three inches. The wound was closed by interrupted catgut sutures. The pericardium having been emptied of blood and blood-clot with the hand and gauze sponges, the pericardium and the wound were closed without drainage. An intravenous saline infusion was given on the table. For the first six or seven days there were signs of pleurisy in the left chest. The wound healed by first intention and the patient made an uninterrupted recovery

W Gissane and B Schulenburg's Case —

Gissane and Schulenburg detail some instructive technical points concerning their patient a man of 23. The pericardium was opened widely and found to be full of blood. In spite of the use of a sucker the heart could not be seen. The hand was passed under the heart, which was gently levered towards the surface. A wound of the anterior surface of the right ventricle about three-quarters of an inch in length could be seen. Blood welled from the wound during diastole, but there was no loss during systole. An apex suture was passed, but it did not prove satisfactory as it soon cut out. Relying on the hand to steady the organ, two control sutures were passed on either side of the wound and the ends were crossed. The wound was closed with interrupted sutures of No 60 thread. The sutures were passed and tied during diastole. The suture line was inspected, and noting that no blood escaped, the control sutures were removed and the heart dropped back.

To their dismay the pericardium was again seen to fill with blood. The hand was introduced into the pericardium and the index finger was able to locate a second wound on the postero-inferior surface of the right ventricle. This wound was closed in the same manner and once again the heart was dropped back and the pericardium sucked dry No attempt was made to close the pericardium. The superficial tissues were sutured around a drainage-tube. A drip blood transfusion was given. The patient recovered.

RETAINED METALLIC FOREIGN BODY IN THE HEART OR PERICARDIUM

Provided active bleeding is not proceeding or suppurative pericarditis has not supervened, there is no urgency for treatment. The surgeon should pause and ask himself whether an operation is really necessary If operation is decided upon the heart is exposed by Spangaro s incision (p. 733)

SUPPURATIVE PERICARDITIS

With the advent of antibiotic therapy suppurative pericarditis, formerly fairly common as a complication of suppurative conditions elsewhere and as a terminal event in a number of medical conditions, has become somewhat of a rarity However the usual type of case which is referred to the surgeon is one which has not resolved under antibiotic therapy

The physician may or may not have aspirated pus from the pericardial sac and have sensitivity tests performed.

Assuming that the diagnosis has been established by a physician, the surgeon should proceed as follows —

1 The patient should be conveyed to the operating theatre on his bed where if his condition warrants it, the necessary procedures can be undertaken without moving him on to the operating table What should be avoided rigorously is aspiration or operation in the ward where (however careful the aseptic ritual) infection by antibiotic-resistant organisms is likely to occur Whether on the operating table or in bed the patient is placed in the semi-sitting position, preferably supported by a back rest.

2. If aspiration has not been performed previously a wide-bore aspiration needle is introduced, after raising an intradermal weal of local anesthetic over the 6th interspace just to the left of the sternum *medial* to the internal mammary artery (*Fig* 1018) There is little risk of traversing the pleural cavity as the suppurative process will have enlarged the pericardial sac The needle is inserted to a depth of 1–2 in. (2·5–5 cm.), depending on the thickness of the subcutaneous fat

Alternatively the needle is inserted at the angle between the xiphisternum and the left costal margin and is advanced upwards at an angle of 45 to a depth of 2–3 in. (5–7 5 cm.).

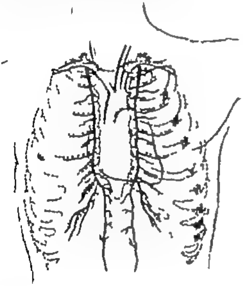

Fig 1018 —The surface marking of the internal mammary artery (*After L. Hosier*)

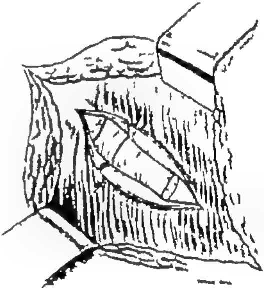

Fig 1019 —Donaldson method of draining the pericardium.

The pericardial sac is aspirated as completely as possible, and the pus obtained is sent for culture and sensitivity tests. Finally 1 000 000 units of penicillin in a small volume (3–5 ml) of sterile water is instilled into the pericardium via the aspirating needle

3. Should aspiration have been performed previously and the sensitivities of the organisms present be known, an adequate dose of the appropriate antibiotic is instilled after complete re-aspiration of the pericardial sac

4 Aspiration and antibiotic instillation are repeated in the operating theatre daily until pus formation ceases, or the pus becomes too thick for aspiration. When possible the rate of pus formation should be checked by daily radiographs of the cardiac shadow Usually however the patient s general condition will indicate whether aspiration is necessary less frequently

5. Should the pus become too thick for aspiration drainage of the pericardium (pericardiostomy) becomes necessary In this respect the principles of treatment resemble those of an empyema thoracis (see p. 711).

Frequently the physician will have carried out aspiration until the pus is too thick to be aspirated, and the surgeon is called in at this juncture

Pericardiostomy for Pyopericardium is best performed under local anesthesia, if need be in the patient s bed but, as emphasized above not in the ward.

Donaldson's Method has the great advantage that dependent drainage is obtained. An incision 3 in. (7.5 cm.) long is made over the junction of the left 7th costal cartilage and the body of the sternum, extending downwards and outwards along the line of this cartilage, which is resected after division of the subcutaneous fat, anterior rectus sheath, and fibres of insertion of rectus abdominis (Technique of rib resection, *see* p. 711). At this juncture it is a wise precaution to introduce an aspirating needle into the pericardium through the bed of perichondrium, to make certain that the correct site has been chosen. The perichondrium is then incised, together with the pericardium (*Fig.* 1019). The superior epigastric artery may be encountered when the perichondrium is incised. It lies deep to the perichondrium almost 1 in. (2.5 cm.) lateral to the sternum (*see Fig.* 1018). The pus is aspirated with a sucker, if available, after which any adhesions within the pericardium are broken down gently with the index finger, and the interior of the pericardial sac is irrigated with warm saline solution.

Finally, a small de Pezzer catheter with its tip removed (or some other type of self-retaining catheter) is left in the pericardial sac and stitched to the skin. The skin is then closed by interrupted stitches. The drainage catheter is irrigated daily with a small quantity of warm saline solution to keep it clear; the tube is removed when the drainage of pus ceases.

If at any stage cardiac arrest occurs the measures detailed on p. [illegible] are instituted.

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Revised by ALLAN CLAIN, M.B. (Cape), F.R.C.S. (Eng.)
Senior Surgical Registrar, Royal Marsden Hospital, London

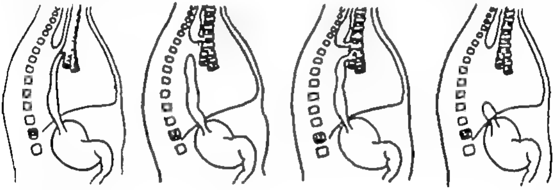
CHAPTER LXI

THE ŒSOPHAGUS

CONGENITAL ATRESIA OF THE ŒSOPHAGUS AND TRACHEO-ŒSOPHAGEAL FISTULA

Congenital atresia of the œsophagus occurs at least as frequently as a cleft-palate. In the great majority of cases it is associated with a tracheo-œsophageal fistula. Referring to *Fig.* 1020 it will be seen that in 90 per cent of cases it is the *lower* blind pouch that communicates with the trachea. It is highly important to be alive to the possibility of this abnormality, because its recognition within 48 hours of birth, and subsequent surgical rectification, is the only hope of survival. Œsophageal atresia is more common in premature than in full-term infants, and in rather a high proportion other congenital abnormalities are also present.

Diagnosis.—The *newborn babe regurgitates all the first, and every feed*, but the diagnosis should be made, if possible, before a feed, or at any rate a second feed, is given. Foamy saliva pours from its nose as well as its mouth almost continuously. This is *the*



85 per cent A | 2 per cent B | 1 per cent C | 12 per cent D

Fig. 1020.—*Congenital œsophageal atresia.* A, *With the lower pouch opening into the trachea*; B, With the upper pouch opening into the trachea; C, With both pouches opening into the trachea; D, With both pouches ending blindly; usually the mid-œsophagus is missing entirely.

sign of œsophageal atresia: to no other condition does this phenomenon appertain. In cases belonging to Type A the infant coughs up frothy mucus, sometimes bile-stained, and attacks of cyanosis, due to stomach contents regurgitating into the trachea, are wont to occur. The abdomen becomes distended because of air swallowed from the tracheo-œsophageal communication. When a newborn child chokes, coughs, and becomes cyanotic, particularly following a feed which is promptly and totally regurgitated, the diagnosis of œsophageal stenosis with tracheo-œsophageal fistula can be ventured with a considerable degree of certainty. A No. 10 soft rubber catheter is introduced into the œsophagus through the nose, and if an obstruction is encountered 4–4½ in. (about 11 cm.) from the nostril, the diagnosis is practically certain.

Radiological Confirmation of the diagnosis is most desirable, for it is absolute. On no account must barium emulsion be given; neither must lipiodol be used. Via the catheter mucus is aspirated from the œsophagus and 1 ml. of a water-soluble opaque medium (e.g. such as is used for intravenous pyelography) is injected down the catheter, the infant being in the supine position so that should the atresia be of Type B or C the medium is less likely to enter the trachea. Radiographs are taken, the lateral radiograph being the most enlightening. The opaque medium is aspirated, but the catheter is left *in situ* so that

the aspiration of saliva can be continued. The radiograph will show the blind upper end of the œsophagus filled with the contrast medium. Another radiographic finding of great significance is the presence of much air in the stomach and upper jejunum, which is indicative of a communication of the lower pouch with the trachea. Conversely in Types B and D the stomach and intestine are bereft of gas, which is also diagnostic. An anteroposterior radiograph of the thorax will reveal the presence and extent of pulmonary atelectasis or consolidation some degree of which is nearly always present.

Pre-operative Treatment.—It is necessary to spend 12–24 hours in overcoming the effects of dehydration and combating varying degrees of pneumonitis, which is so often present. If the signs so dictate postural drainage of the lungs should be carried out by placing the infant in the head low face-down position. As soon as signs of obstruction to the tracheobronchial tree are absent the position is changed to Fowler's position, to minimize gastric secretions entering the tracheobronchial tree through the fistula. Constant suction of the contents of the blind pouch by means of a No 6 French rubber catheter with a number of holes cut in its distal extremity is essential, and it requires the services of a special nurse to ensure that the catheter is functioning satisfactorily An oxygen tent is often required. Intravenous 5 per cent dextrose solution alternating with small quantities of dextrose-saline is administered by cannulizing the internal saphenous vein. It is wise not to continue to use the same vein for more than 48 hours, because of the danger of phlebitis. Vitamins (parenterovite see p. 31) should be added to the parenteral fluid. Penicillin, 30,000 units, and streptomycin, 10 mg per pound of body weight, are given intramuscularly 8-hourly

If abdominal distension is excessive gastrostomy by the ink pot method (see p. 308) should be performed through a left split rectus incision under local anæsthesia; this allows the gas to escape and the opening can be employed for the drip administration of dextrose solution.

Anæsthesia.—Most operators experienced in this operation are satisfied with endotracheal anæsthesia on the other hand Gross prefers cyclopropane-oxygen given through a well-fitting face-piece. This, he finds, minimizes tracheitis and post-operative pulmonary œdema due to rupture of alveoli. A well-fitting face-piece permits a transpleural operation, for the lung can be sufficiently inflated from time to time.

Operation.—During the operation a small blood transfusion, totalling about 10 ml. per lb of body weight, is gravitated throughout the operation. The child is placed with the right side uppermost, the right arm being drawn up out of the way A long incision is made between the 4th and 5th ribs (*Fig* 1021) and, after transecting the muscles of the chest wall, the intercostal space is entered, this being opened throughout the length of the incision. It is rarely necessary to divide a rib posteriorly or a costal cartilage anteriorly for the soft ribs of an infant bend and are separated easily A self retaining retractor is inserted. The lung is retracted away from the field of operation. The first duty is to doubly ligate and divide the azygos vein as it enters the superior vena cava. This accomplished, a long incision is made through the parietal pleura over the length of the œsophagus, and the resulting flaps (*Fig* 1021) are dissected up with great care, so that they can be utilized to cover the anastomosis towards the end of the operation. Attention is directed to the upper blind œsophageal pouch If it cannot be located easily the anæsthetist introduces a catheter into it. Three deep sutures are passed through its bulbous end, and the pouch is dissected right up to the apex of the thorax. Especial care is necessary when separating the pouch from the trachea. Using the traction sutures, and keeping the dissection close to the œsophageal wall is the only way to avoid wounding the trachea. Should the trachea be opened inadvertently the opening must be closed immediately with interrupted silk sutures. Attention is then directed to the lower portion of the œsophagus. About its middle the entire periphery of the œsophagus is dissected free and raised from its bed. While this is being undertaken great care must be exercised not to injure the vagi or their main branches, and on the left side of the œsophagus the left pleural membrane must remain intact. A piece of tape is passed around the œsophagus, which enables the dissection to be carried out more easily in an upward direction as far as, and including the tracheo-œsophageal fistula and downwards as far as is thought necessary to allow sufficient mobilization to bridge the gap. The dissection of the lower œsophagus must be particularly gentle, because it lacks both the generous blood-supply and the hypertrophy found in the proximal segment. The fistulous communication between the trachea and the œsophagus is now

severed, and the opening in the trachea is closed with interrupted 00000 silk stitches. Over the opening usually it is possible to bring together adventitious tissue to bury the suture line partially always being watchful not to constrict the trachea. The small opening in the œsophagus is dilated until the orifice is a size suitable for anastomosis. Should this not prove facile a V-shaped piece is removed from the side wall of the distal end so as to minimize disproportion when the two segments are anastomosed It is important to be certain that the blood-supply of the distal end is adequate If it does not bleed readily

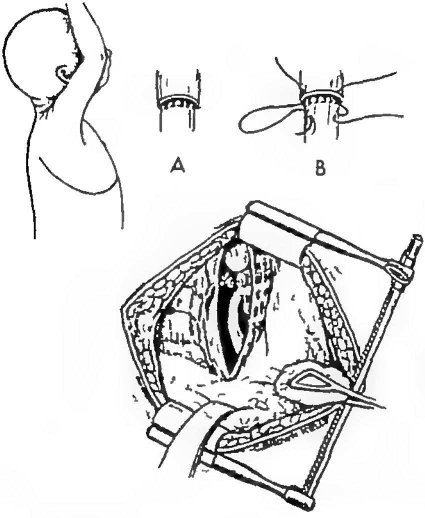


Fig 1021 —Thoracotomy for œsophageal atresia. The posterior mediastinal pleura has been incised to give access to both ends of the œsophagus ; A, Anastomosis of the full thickness of the œsophagus below to the mucosa of the upper pouch ; B, The dissected muscularis is brought over the suture line

a little of it must be resected. The upper œsophageal pouch is opened, and for 3–4 mm. its mucous membrane is dissected from the muscular coats. The mucous membrane of the upper pouch is anastomosed to the entire thickness of the open end of the lower pouch, the No. 8 French catheter lying in the proximal segment being passed from one pouch to the other after one-third of the circumference has been united with fine silk With the catheter in place the remaining interrupted sutures (*Fig* 1021 A) can be inserted readily If the anastomosis has sufficient tension on it to make one hesitate as to whether it is safe to feed across it early a small polythene tube with a rubber catheter tip is threaded down into the stomach before the anterior row of sutures is inserted The cuff of muscularis of the upper segment is drawn over the suture line (*Fig* 1021 B) and anchored to the

lower segment by a second row of interrupted sutures, thus ensuring a perfectly water tight junction. The flaps of parietal pleura are brought over the œsophagus, leaving a small portion unsutured at either extremity so that blood or serum will not accumulate in the mediastinum. A No 12 catheter with several additional holes cut in its distal end is passed through a small stab incision in the 8th intercostal space in the mid-axillary line The thoracotomy wound is closed with pericostal sutures of fine chromic catgut and the muscles of the chest wall are brought together with a continuous stitch of the same material. The subcutaneous tissues are sutured with a further continuous suture and the skin is closed with continuous fine silk. Fluid and air are removed from the pleural cavity by suction applied to the intercostal catheter with a syringe thus giving a negative pressure to expand the lung The catheter is clipped and later connected to a water-sealed bottle

In cases belonging to Type D the best course is to incise the diaphragm and, having mobilized the fundus and, if necessary a part of the body of the stomach by dividing its omenta between ligatures the stump of œsophagus with its attached mobilized stomach is brought into the thorax, where an anastomosis can be made between the two ends of the œsophagus without tension. The diaphragm is approximated around the stomach, to which it is anchored.

After-treatment.—Following the operation the infant needs plenty of oxygen in a warm moist atmosphere. A nurse ready to pass a catheter into the œsophagus and apply suction, must be in attendance night and day Parenteral fluid, mostly 5 per cent dextrose solution, is administered, about 250 ml. being required daily Feeding by mouth through the nasogastric tube or through the gastrostomy is started on the second day commencing with 10 per cent solution of dextrose 2–3 oz. (60–90 ml.) at a time at frequent intervals, and adding milk by the fourth day It should be remembered that the stomach of these patients is unusually small, and overdistension will cause regurgitation of the stomach contents up the œsophagus. When a tube is in place, the safest method is to give these feeds by gravity drip, and to spend half an hour in each administration. By the end of the third week the infant is able to take full feeds by mouth. Antibiotics are continued until all evidence of pulmonary infection has disappeared.

Complications.—

Respiratory Obstruction necessitating tracheostomy arises occasionally

Leakage of the Anastomosis is not necessarily fatal. Gastrostomy should be performed and drainage of the pleural cavity continued. Re-operation is seldom successful. Sometimes the fistula closes spontaneously

Foreign Bodies in the Œsophagus (see p. 854).

PERFORATION OF THE PHARYNX OR THE ŒSOPHAGUS DUE TO INSTRUMENTATION OR FOREIGN BODY

Perforation due to Instrumentation.—On rare occasions during the course of an œsophagoscopy or gastroscopy the instrument causes a perforation usually such a tear is in the cervical œsophagus or the pharynx just above the cricopharyngeus muscle and especially liable to occur in a child. However the most common cause of perforation of the œsophagus is a sharp-pointed foreign body plus instrumentation to remove it Dilatation of a stricture and a biopsy specimen taken from the œsophageal wall are at one time or another also the cause of perforation.

Often the perforation goes unrecognized by the œsophagoscopist until the patient has been returned to the ward, when general distress, pain on swallowing saliva or fluid, and dyspnœa become apparent The possibility of a tear should be considered at once surgical emphysema sometimes develops in the neck or a pneumothorax may be detected on clinical examination. An X ray examination is essential If a perforation has occurred this frequently discloses the presence of air in the mediastinum, pleural cavity or in the neck. In doubtful cases the radiograph should be repeated after the patient has swallowed a small quantity of lipiodol.

Treatment —Penicillin and streptomycin having been administered, immediate operation is required If the tear is in the cervical œsophagus or the pharynx, lateral pharyngotomy (see p. 850) is performed, and a hæmatoma will be seen in the peri-œsophageal tissue this is evacuated and leads to the tear which is sutured in two layers. The wound is drained and a temporary gastrostomy performed.

If the tear is in the thoracic œsophagus, a full thoracotomy is carried out. Fluid and air will be found in the pleural cavity. Once more the guide to the tear follows evacuation of the peri-œsophageal hæmatoma and scrutiny of its bed. Suture of the perforation, intercostal closed drainage and temporary gastrostomy are the logical steps for dealing with this catastrophe.

Many patients have survived the prompt recognition and treatment of this condition.

Mediastinitis following Instrumentation or Removal of a Foreign Body.—When the symptoms are not those of acute perforation but are more delayed and consist of substernal or epigastric pain, pain in the back associated with pyrexia, and radiography is negative, massive antibiotic treatment is usually successful. In these cases actual rupture of the œsophagus is not necessarily present, but rather fissuring of the œdematous, friable mucous membrane, through which organisms escape into the mediastinum (H. D. Adams). When the reaction is severe it is wise to perform temporary gastrostomy in order to rest completely the abrasion or small perforation.

SPONTANEOUS RUPTURE OF THE ŒSOPHAGUS

The findings at operation or necropsy[1] are remarkably constant. There is a clean-cut longitudinal tear 1–8 cm. in length on the left posterior wall of the extreme lower end of the œsophagus (*Fig.* 1022).

The probable explanation of the bursting of the œsophagus is as follows: instead of the cricopharyngeus relaxing, as is usually the case during vomiting, it contracts. The pharyngeal and the pyloric sphincters being closed, the intra-œsophageal and intragastric

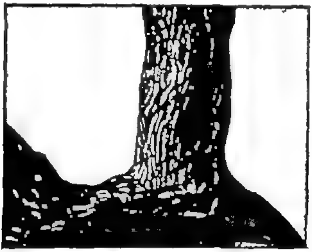


Fig. 1022.—Spontaneous rupture of the œsophagus. (*After S. A. Mackler.*)

pressure rises abruptly far above anything that is experienced ordinarily and the œsophagus bursts at its weakest part. The weakness of the muscular coat at this site is related to the entrance of a neurovascular bundle. The inco-ordination of muscular contraction during vomiting can occur from the toxic action of alcohol on the vomiting centre. Following perforation, the posterior and then the anterior mediastinum become filled with air and gastric contents, and in a matter of an hour or two the mounting pressure in the anterior and posterior mediastinum dissects along the tissue planes to the superior mediastinum: thus gas finds its way into the loose areolar tissues at the root of the neck.

Usually about 6–8 hours later the pleural membrane gives way at one point, and air and gastric contents gush into the pleural cavity.

Diagnosis.—Eighty-five per cent of the patients are males. They are usually in the third and fourth decades, and a high proportion have a history of alcoholism. Following a heavy meal there is vomiting, and during or immediately after vomiting agonizing pain

[1] In 19 cases of spontaneous rupture of the œsophagus found at necropsy at Newcastle upon Tyne General Hospital, 17 were associated with a lesion, often traumatic, of the central nervous system. Possibly vomiting and retching in these cases accounted for the rupture. (I. N. MacIver.)

is experienced in the left (rarely the right) side of the thorax, radiating to the back. Vomiting usually ceases with the onset of rupture, but should it continue the vomitus is usually streaked with bright red blood. Soon surgical emphysema appears in the suprasternal notch; it spreads up and around the neck. Crepitus is often detected here within one hour after the rupture (S. A. Mackler) The pain is so intense that morphine fails to relieve it. There is an insatiable thirst and if the patient is allowed to sip water this is followed immediately by accentuated pain in the chest.

Nota bene The triad of (1) vomiting followed by (2) excruciating pain in the lower thorax, and (3) emphysema of the neck constitutes sufficient evidence to warrant immediate left thoracotomy When perforation of the pleura has taken place hyper resonance and absence of breath sounds over one lung strongly suggest a (hydro)-pneumothorax which, indeed, is present. It is to be emphasized however that a hydropneumothorax indicates a lapse of time sufficient for pleural perforation, whereas early diagnosis is the essence of a successful issue.

To suspect the diagnosis is to make it, if the condition exists. It should be noted particularly that vomiting *precedes* the pain that the upper abdomen is usually rigid and that in really early cases there are *no signs* in the thorax, for the gas and fluid are confined to the mediastinum. When the pleural cavity becomes involved the general course is rapidly downhill with dyspnœa cyanosis, and impending vascular collapse.

Differential Diagnosis.—The condition has many times been mistaken for perforated peptic ulcer and frequently an emergency laparotomy has been performed. In perforated peptic ulcer the pain appears first, and this may be followed by vomiting, whereas in spontaneous perforation of the œsophagus vomiting precedes the pain. When pleural involvement has occurred the diagnosis of spontaneous pneumothorax following a pathological condition of the lung has from time to time been made The radiographic findings (*see below*) make the differentiation possible. The condition also has been confused with acute pancreatitis, coronary thrombosis, mesenteric thrombosis, and dissecting aortic aneurysm.

Radiography.—Cervical or mediastinal emphysema is seen on the film in 60 per cent of cases. In other *early* cases there are no X-ray signs in the thorax. The absence of subdiaphragmatic gas in all cases is of some help in differentiating the condition from perforated peptic ulcer The radiographic finding of hydropneumothorax is quite diagnostic, and the presence of fluid occurring simultaneously with a pneumothorax differentiates ruptured œsophagus from spontaneous pneumothorax. If a small quantity of lipiodol is swallowed, sometimes the site of perforation can be demonstrated.

Aspirating the Pleural Cavity is most helpful if the pleural cavity is involved. Fluid acid to litmus, and gas, are withdrawn. A small quantity of methylene blue solution taken by mouth, and appearing in the fluid obtained by thoracentesis, offers conclusive proof of the diagnosis.

Pre-operative Treatment.—Supportive therapy should be intense, consisting of intravenous dextran, blood transfusion, antibiotics, and the administration of oxygen by means of nasal catheters. Gastric aspiration should be performed but the operator must be certain that the tube is not in the mediastinum.

Operation.—Left thoracotomy (*see* p. 729) should be performed as soon as possible. The mediastinal pleura is incised throughout its length, to decompress all loculated areas within the mediastinum and allow free drainage into the pleural cavity The rupture is closed with interrupted sutures, and the pleural cavity is drained by means of a closed drainage system. Should the condition of the patient not warrant thoracotomy intercostal drainage of the pleural cavity performed, if necessary in the patient's bed, can be used as a temporary expedient to be followed by the major operation should the condition of the patient improve

Post-operative Treatment.—In addition to the treatment of shock, intensive oxygen and antibiotic therapy are continued as long as necessary

MASSIVE HÆMORRHAGE FROM ŒSOPHAGEAL VARICES

Although called œsophageal it is important to realize that these varices extend well into the stomach. If the patient is known to have hepatic cirrhosis, that the hæmorrhage is coming from œsophageal varicose veins should be assumed although it is not a

curiosity for a patient with cirrhosis of the liver to suffer also from a gastric or duodenal ulcer Unless the hæmorrhage is torrential, the first things to do are :—

1 Treat the Patient by Conservative Measures alone.—These include a sedative (barbiturates, after an initial dose of morphine), blood transfusion, followed by transfusion of packed red cells (so as not to embarrass the general circulation) and the administration of vitamin K (which is deficient in hepatic disease). The slow administration of 20 units of obstetric pituitrin in 200 ml. of saline solution lowers portal pressure and is of proven value (W D Davies). Rest, sedation, and blood replacement will carry approximately 50 per cent of patients past the crisis.

2. Treatment by Means of a Hæmostatic Balloon has proved an effective emergency *measure for controlling the hæmorrhage, at least temporarily*

(*a*) *An Improvised Balloon*.—To the end of a gastric aspiration tube a child's small balloon is bound firmly with silk. After the tube has been passed into the stomach the balloon is inflated with water and the proximal end of the tube tied with a strong piece of silk. The inflated balloon is then drawn up against the cardio-œsophageal junction, where it is maintained firmly by strapping the tube to the cheek while moderate traction is exerted.

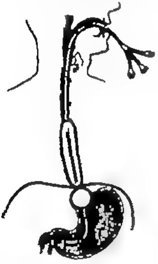


Fig 1023. —The Sengstaken tri lumen tube and balloon.

(*b*) *The Sengstaken Balloon*[1] (*Fig* 1023), almost without exception will control bleeding[2] if inflated adequately Ascertain which lateral tube-mouth is connected with the stomach and œsophageal balloons respectively Render the apparatus surgically clean, as directed on p. 108 The patient is propped up with pillows, and the nostrils and the posterior pharyngeal wall are sprayed with 4 per cent xylocaine solution. The balloons and the distal end of the tube are smeared with lubricating jelly and thrombin. The tube is inserted into the nostril or the mouth, until its extremity appears in the pharynx. The patient is instructed to swallow sips of water while the tube is advanced until the 50-cm. mark reaches the nostril The stomach balloon is then inflated with 100–200 ml. of air and before detaching the syringe the screw-clamp of an infusion apparatus is employed to compress tightly the commencement of the tube leading to the stomach balloon. The tri lumen tube is withdrawn until resistance is encountered It is then strapped to the cheek while exerting moderate tension upon it The œsophageal balloon *is inflated with 40–60 ml. of air which is* prevented from escaping by another screw-clamp.

The amount of traction on the tube and the degree of inflation of the balloons are adjusted until bleeding ceases. The gastric aspiration component is utilized energetically for aspiration (and, if necessary irrigation) until the stomach seems clear of fluid blood. Aspiration is then continued at regular intervals.

Treatment with a hæmostatic balloon has a number of shortcomings. If it is left in place over 72 hours, œsophageal ulceration and rupture has been known to occur Saliva fills the œsophagus, and is liable to be inspired unless it is aspirated by another tube periodically In young children the balloon can cause tracheal displacement and compression ; should the balloon rise into the pharynx total obstruction of the airway will occur Tracheostomy although obviating these dangers, has a danger of its own in this instance namely bleeding from the wound owing to prothrombin deficiency *Lastly renewed hæmorrhage as soon as the balloon is deflated occurs in a* significant number of instances. Seventy two hours of tamponade usually is tolerated fairly well.

3. Trans-œsophageal Ligation of the Varices.—So often does hæmorrhage occur after removal of a hæmostatic balloon that suture of the varices is indicated frequently In cases where bleeding persisted in spite of purely conservative treatment or was extreme

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[1] Supplied by J G. Franklin and Sons Ltd., London Davol Rubber Co. Providence Rhode Island U.S.A.

[2] It is therefore a diagnostic test since it effectively stops hæmorrhage from œsophageal varices thus obviating patients in danger of death from hæmorrhage to barium swallow studies, and even œsophagoscopy

reliable method of securing an interval of a few weeks without further œsophageal bleeding, during which time adequate preparation for the elective procedure is made possible.

Evacuation of Blood from the Alimentary Canal.—No one questions the importance of stopping the bleeding but the basic necessity of clearing the blood from the gastro-intestinal tract as soon as possible is frequently neglected from sheer ignorance of its potential danger. Digested blood is brimful of concentrated amino-acids which, if carried to a liver unable to metabolize them, quickly bring about hepatic coma. Therefore no time must be lost in aspirating all blood from the stomach, giving milk of magnesia in tablespoon doses through the tube hourly combined with enemas and colonic irrigation until all the blood and semi-digested blood has been evacuated.

THE MANAGEMENT OF CORROSIVE BURNS OF THE ŒSOPHAGUS

The corrosive acids are strong sulphuric, nitric, and hydrochloric acids; the corrosive alkalis are caustic soda, caustic potash, and strong ammonia. Caustic soda is the most common of all corrosives to be swallowed.

Obviously the first duty is to wash out the stomach with the correct neutralizing agent. Not more than 1 pint (500 ml.) in an adult and ¼–½ pint (125–250 ml.) in children should be gravitated at one time; more than a pint endangers rupture of the corroded stomach.

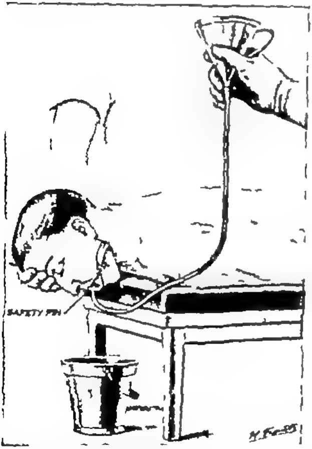

Fig. 1023.—Washing out the stomach. For the sake of clarity the operator's hand holding the tube and the assistant's hands holding the mouth gags in place are not shown.

For neutralizing corrosive alkali 3 oz. (90 c.c.) of vinegar or the juice of half a dozen lemons to the pint should be employed. For neutralizing corrosive acids the best agent is magnesia, either mag. ox. lev. or mag. ox. pond. 4 teaspoonfuls to the pint should be employed. If magnesia cannot be obtained in time, chalk, soap-suds, or washing soda can be used.

It is better to wash out the stomach with plain water than to waste time in searching for the antidote which can be added to the stomach wash as soon as it arrives.

Equipment.—(1) A Jacques rubber stomach tube. For adults the tube should not be less than ½ in. (1·3 cm.) in diameter. These tubes are commonly made either 30 or 60 in. (75 or 150 cm.) in length; the longer tube is preferable. For children of 2 years and under a No. 16 English catheter is convenient. Before the tube is passed the distance to which it should be inserted must be marked by the insertion of a safety pin through its walls, but not through the lumen of the tube. For an adult the pin is inserted 20 in. (50 cm.) from the tip of the tube; for infants of 2 years or less, 10 in. (2) A funnel. (3) Two mouth gags. (4) Towel clip to retract the tongue. (5) Two jugs. (6) A pail.

It is of paramount importance to place the patient in the position shown in *Fig.* 1023. False teeth are removed when present. The operator sits or kneels while passing the tube, a mouth gag being in place on each side of the mouth. If possible one assistant should be delegated to make the control of the gags his sole concern (H. L. Marriott). The lubricated tube is passed into the stomach, and tepid water is introduced and siphoned back, never exceeding 1 pint (in an adult) or ½ pint (in children). The first wash-out should be set aside for subsequent analysis. The wash-outs are continued 1 pint at a time until

16 pints have been used The volume of the returned fluid must be checked at the end, to make sure no fluid is unaccounted for Loss of an appreciable quantity suggests perforation of the stomach.

Treatment of shock is the next consideration and tracheostomy instruments should be available immediately should œdema of the glottis ensue.

Effects of the Burn.—Acids produce a coagulation necrosis with an action limited to the superficial layers of the œsophagus whereas alkalis cause a liquefying necrosis, and penetrate much deeper Severe burns usually occur in the middle and lower thirds of the œsophagus. *There are three distinct phases of a severe œsophageal burn* :—

The Acute Phase lasts up to two weeks and commences with superficial necrosis and sloughing of the mucosa ; it is followed by œdema of all the layers In severe burns there is dysphagia, retrosternal pain, and dehydration—all of which must be combated.

The Intermediate Phase is characterized by separation of the slough, which leaves behind angry red granulations surmounted by elongated ulcers This phase lasts two to four weeks, and shows decrease in the dysphagia.

The Final Phase is characterized by fibrosis. Dysphagia again manifests itself and this time it tends to become progressive because of stricture formation.

More Remote Treatment.—*In the acute phase* gastrostomy is advisable in severe burns and the only method of determining whether the burns are severe is by œsophagoscopy From the commencement antibiotic therapy is essential, and full doses of penicillin and streptomycin cannot be bettered

In the intermediate phase to help to minimize the formation of scar tissue, the administration of cortisone is recommended by some If cortisone is employed, the chances of considerable infection and perforation of the œsophagus are more likely Hence it cannot be used without additional risk.

From this point there are two schools one is for early dilatation this school appears to be losing ground. The other is for delayed bouginage The objections to each seem justified. The opponents of immediate active treatment stress the danger of perforation and further trauma during the acute stage certainly if bouginage is employed at this time only a soft tube (which can be used for feeding purposes) should be inserted. Those opposed to delayed treatment believe that valuable time is lost and that more scarring and contracture will occur if active treatment is delayed. There can be no doubt that when the burns are severe, or of moderate severity gastrostomy by the ink pot method has much to recommend it it gives the inflamed œsophagus rest minimizes infection of the burnt area, minimizes pain and permits full nutrition to be maintained.

The treatment of stricture of the œsophagus is beyond the scope of this work.

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CHAPTER LXII

FOREIGN BODIES IN THE AIR PASSAGES

By Cecil P Malley B Ch., F R.C.S. (Eng), F I C.S.

Surgeon Metropolitan Ear Nose and Throat Hospital, London

Depending upon the site of impaction and the degree of respiratory obstruction the symptoms due to the presence of a foreign body in the air passages vary from those of suffocation with a speedy death to no symptoms at all.

Fluid (e.g inhaled vomitus, blood) always flows, or is sucked into the trachea and bronchi. A comparatively larger piece of semi-solid material (e.g., a piece of chewed meat blood-clot, a collection of detached adenoids) tends to become impacted in the vestibule of the larynx, causing fatal asphyxia if it is not coughed out a large blood-clot is notorious in this respect. On the other hand a piece of such material small enough to pass through the rima glottidis is drawn into the trachea, where it may become arrested at the bifurcation. Thin circular objects such as coins flat buttons, and button-shaped squeakers tend to become impacted edgeways in the rima glottidis, where they lie in the sagittal plane

The presence of a foreign body in the air passages causes immediate reflex coughing choking, wheezing dyspnœa, great mental distress, and, on occasions, asphyxia. When the obstruction is severe the patient holds on to some convenient object and all the accessory muscles of respiration are called into play If the foreign body is not coughed out there is a tendency for it to be drawn further into the bronchial tree. More often than not, in its new situation the object causes less obstruction, consequently a quiescent, comparatively symptom-free stage ensues. This deceptive state especially in the case of vegetable foreign bodies, is short lived, since tissue reaction or swelling of the object often causes renewed symptoms.

For clinical purposes inhaled foreign bodies can be divided profitably into vegetable and non vegetable.

Vegetable Foreign Bodies—Such an object as a nut, an orange pip, or an ear of corn causes especially violent symptoms of coughing dyspnœa and copious sputum due, in part to irritating proteins common to such substances. If the foreign body is small enough to pass the glottis it may cause tracheal obstruction by swelling in its moist environment or as a result of the tissue response it provokes. The tissue reaction is severe and it spreads throughout the tracheobronchial tree rapidly causing acute and (unless the foreign body is removed within 12 hours of its inhalation) not infrequently fatal bronchopneumonia. *Likewise should a vegetable foreign body be arrested in a bronchus a similar though more* localized pneumonitis results.

Non-vegetable Foreign Bodies do not cause a severe reaction Their presence is sometimes unsuspected until they cause local atelectasis or early in the case of an infected tooth, lung abscess.

The patient does not always distinguish between a swallowed and an inhaled foreign body and speaks of every such episode as having "swallowed the object The surgeon must explain the difference to him and make a point of asking whether he choked or coughed. If the history is suggestive of a patient having *inhaled* a foreign body *bronchoscopy should be performed, even if radiographs of the chest are negative* Many plastic materials are radio-translucent and dentures are often without metallic parts.

F Bauer's Case.—

Œsophagoscopy had been performed elsewhere on the patient's history of having swallowed a bone; radiographs of the thorax were negative The patient developed a lung abscess. F Bauer performed bronchoscopy and removed a bone from the right main bronchus.

SITES OF IMPACTION OF A FOREIGN BODY

1 Tonsil and Fauces.—The patient complains of pain behind and below the angle of the jaw especially on swallowing Commonly a herring bone is arrested at this site, and a strong light is needed to see it projecting from the tonsil. It can be removed by grasping it in a long hæmostat.

2. Piriform Fossa.—Frequently a long sharp fish bone or a rabbit rib becomes impacted in this situation causing pain at the root of the neck It is best visualized by indirect laryngoscopy (see p. 731) and removed with a right-angled laryngeal forceps. Direct laryngoscopy is also suitable

3. The Larynx.—Impaction at the rima glottidis is the commonest cause of complete respiratory obstruction and sudden death The foreign body wedged into the funnel shaped vestibule by the pharyngeal sphincter during the act of deglutition is held firmly by the reflex spasm of the cords and the aryepiglottic folds. If the obstruction is not complete œdema of the glottis soon makes it so In either event in the presence of asphyxia immediate tracheostomy is the only measure likely to succeed.

4. The Trachea.—A solid body is not often arrested in the trachea because, except in early infancy the lumen of the trachea is greater than that of the glottis. Consequently a solid object that has passed the glottis is likely to be drawn during inspiration into one of the bronchi where it becomes lodged. On the other hand on rather frequent occasions viscous material such as a large blood-clot is liable to become arrested at the bifurcation of the trachea, where it causes complete respiratory obstruction by blocking both main bronchi. The cardinal sign of the latter condition is *silent tracheostomy* Although the trachea has been opened, no air enters or leaves the lungs, even with artificial respiration Almost as a reflex act the trachea distal to the opening should be explored with a long hæmostat with good fortune the offending material can be broken up or seized and withdrawn.

Fig 1026.—Radiograph showing a safety pin in the left bronchus. (*M D A Crow's case*)

A J Wright's Case —

An adenoid curette was used, but no adenoids were retrieved; respiration ceased suddenly and was not resumed. Tracheostomy was performed on opening the trachea the absence of all breath-sounds was extremely striking The only noticeable point in which the case differed from an anæsthetic overdose was the entire absence of the entry of air on artificial respiration. By means of a long hæmostat a mass of adenoids was removed from the bifurcation of the trachea. The child recovered.

5. A Bronchus.—When the foreign body is arrested in a bronchus the symptoms are not nearly so compelling as when an object becomes impacted in the larynx or trachea indeed, there may be no dyspnœa unless the patient exerts himself. When the foreign body is of such a shape that it does not fill the whole lumen of the bronchus (*Fig* 1026) the symptoms are often few; cough and local pain are probable. The bronchi dilate during inspiration and contract during expiration, the variation of calibre of a main bronchus amounting to 20 per cent. Therefore when a foreign body becomes lodged in a main bronchus air can enter the affected lung comparatively readily but on expiration it must traverse a passage much reduced in size an asthmatoid wheeze is produced that is best heard at the mouth, and râles are often present. When the foreign body is round or oval the lumen of the bronchus becomes blocked but at first during expiration only Air enters the lung but none can pass out (ball valve type of obstruction) and an emphysematous condition results (*Fig* 1027) with displacement of the mediastinum towards the healthy side the diaphragm does not rise on the affected side during expiration (*Fig* 1028).

At a later stage complete bronchial obstruction (stop-valve type of obstruction) due to swelling of the foreign body or œdema of the bronchial mucous membrane supervenes. Radiographs will show obstructive pneumonitis with decreased volume of the lung and a slight shift of the mediastinum to the affected side during expiration. Hyper resonance is replaced by impaired resonance.

When a secondary or a smaller bronchus is obstructed the disturbance is often slight and the physical signs are limited to those of atelectasis and râles. An inorganic foreign body causes relatively little local reaction and may remain comparatively mobile; thus it may pass from one bronchus to another.

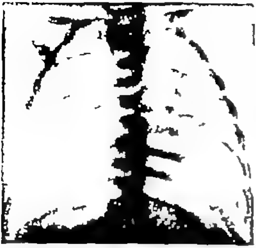

Fig. 1027.—Radiograph showing emphysema of the right lung due to intermittent obstruction on inspiration. Case of peanut in the bronchus.

Fig. 1028.—The same on expiration. The translucency of the right lung persists, while expulsion of air from the left lung causes it to appear relatively opaque. (*Sir Victor Negus's case.*)

Radiographic examination should be undertaken in every suspected case. The majority of inhaled foreign bodies are translucent to X rays, but the radiograph affords valuable evidence of changes in the lung. If the body is opaque, two radiographs in different planes should always be taken. Reference to the surface marking for the bronchial tree (*see Fig.* 1038) enables the surgeon to located the foreign body. Unless the object lies in the centre of the field, allowance for parallax is necessary.

INHALED VOMITUS

Too often vomitus is inhaled through failing to empty the stomach before administering an urgent general anæsthetic to an unprepared patient. If a general anæsthetic is given to a patient with intestinal obstruction, unless a cuffed endotracheal tube is employed there is no guarantee that this complication will be circumvented entirely, even by careful gastric aspiration before, during, and after the operation. Sometimes vomitus is inhaled in the early stages of severe systemic infections in children.

The vomitus fills the trachea and bronchi, causing a varying degree of respiratory obstruction. Should the patient survive a flooding of the bronchial tree, severe tracheobronchitis ensues within 24 hours. At all times the inhalation of vomitus is to be regarded as a most serious condition.

Treatment must be energetic. The patient is turned on to his face with the shoulders lower than the buttocks. A mouth-gag or a bite-block is inserted, the tongue pulled forwards, and the pharynx is cleared with the index finger and a suction tube (do not use swabs; they are comparatively ineffective). Children may be shaken vigorously by the feet. Should the patient fail to breathe, tracheostomy must be carried out and the trachea aspirated through the opening. In less urgent cases an endotracheal catheter can be passed through a laryngoscope and suction applied while a bronchoscope is being prepared for use. The bronchoscope is then passed and the trachea and bronchi are aspirated as completely as possible. Any patient who is thought to have inhaled vomitus must be kept in hospital for at least 48 hours, because of the probability of tracheobronchitis. Antibiotic therapy should be commenced as soon as the airway has been cleared.

REMOVAL OF A FOREIGN BODY FROM THE AIR PASSAGES : OPERATIVE PROCEDURES

Indirect Laryngoscopy.—*If simple measures fail and when the patient is not a child* the larynx should be investigated by means of a laryngeal mirror.

The examination set with the source of light obtained from a battery in the handle (*Fig* 1029 A) is the most convenient; otherwise a head mirror with indirect lighting and a laryngeal mirror may be used.

Anaesthesia.[1]—The patient should first be given two benzocaine tablets to suck; following this, his fauces are sprayed with 10 per cent cocaine. He is instructed to pull out his own tongue and the back of his pharynx is sprayed. In between the spraying, time must be allowed for the patient to spit out so that he does not swallow too much cocaine. The side of the pharynx and the laryngeal nerves can be anaesthetized by means of two long probes with a right-angled bend, and with the ends of the probes serrated so that cotton-wool can be twisted around them; they are dipped in 10 per cent cocaine and inserted into each side of the pharynx and piriform fossæ where they are held for a few minutes.

Fig 1029.—Mirror laryngoscopy. Showing the relative positions of the examiner and the patient. Note the head is being steadied by an assistant. A, Self illuminating laryngeal mirror.

Technique.—The patient is instructed to hold his tongue with a piece of gauze so that one of the examiner's hands is left free to use a curved laryngeal forceps to grasp the object if it can be seen. The patient should, if possible, be placed seated on a chair with a firm back and the examiner sits comfortably facing him. It is an advantage to have someone to hold the patient's head. The examining mirror should

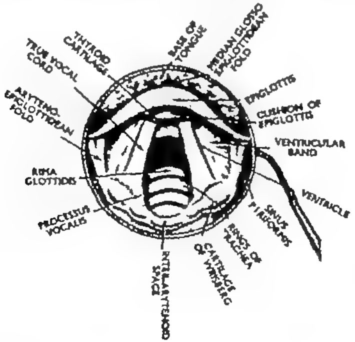

Fig 1030.—Indirect laryngoscopy. *Enlargement of the laryngeal image during inspiration.*

[1] No anaesthesia is required for indirect laryngoscopy as a method of examination—only when it is to be used for removal of a foreign body.

be warmed by passing it through the flame of a spirit lamp or by holding it in a bowl of hot water. It is important to test the mirror on the back of the examiner's hand before use because if it is introduced too warm the patient's confidence is lost. The mirror is passed into the mouth so that the back of it comes to lie against the uvula (*Fig.* 1029), bringing the vocal cords into view (*Fig.* 1030). The method needs a good deal of patience and skill on the part of the examiner and co-operation on the part of the patient.

Remember that the image seen in the mirror is reversed anteroposteriorly but is true laterally. Even if the foreign body cannot be removed by this procedure its shape and position can often be established.

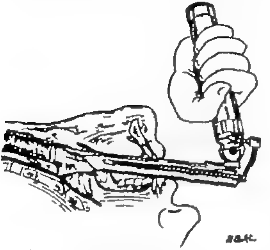

Fig. 1031.—Direct laryngoscopy. Magill's instrument in use.

Direct Laryngoscopy.—This method is indicated: (*a*) in young children; (*b*) if the indirect procedure is not practicable or has failed in adults; and (*c*) when there is a large impacted foreign body. By this method the tissues are looked at directly and if necessary they can be palpated by a probe.

Anæsthesia.—Local anæsthesia is the method of choice except in young children; if not successful it can be followed by an intravenous thiopentone anæsthesia combined with a relaxant. There is a danger of laryngeal spasm during the induction phase of both inhalational and intravenous anæsthesia. The patient first of all sucks two benzocaine tablets and then the oral pharynx and larynx are sprayed as described under indirect laryngoscopy. A suitable dose of pethidine should be administered pre-operatively. Morphine should be avoided because of its depressing effect on the respiratory centre.

Even when it is intended to administer a general anæsthetic, preliminary local spraying is a great help. When respiratory obstruction is so severe that a general anæsthetic is inadvisable the best plan is at once to perform tracheostomy under local anæsthesia. If the foreign body is in the larynx a general anæsthetic to facilitate laryngoscopy can now safely be administered.

Instruments.—A laryngoscope having interchangeable blades and obtaining its source of illumination from a battery in the handle, such as the Magill type (*Fig.* 1031), is the most

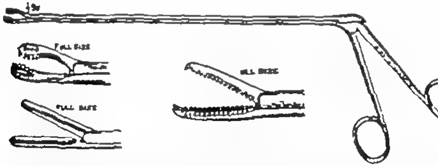

Fig. 1032.—Forceps for use with laryngoscope.

suitable, but in an emergency any pattern of laryngoscope can be used. A laryngeal forceps which is long enough to project beyond the tip of the laryngoscope (*Fig.* 1032) and a number of probes, around the end of which cotton-wool can be wrapped, should be at hand. (These may be needed to anæsthetize the larynx further.) A suction tube should be to hand.

Before commencing the examination the patient must be reassured that the procedure is not dangerous and that all that is necessary for a complete examination is for him to relax and breathe easily. *The patient is placed supine upon the operating table.* The leaf of the head of the table is let down completely and the patient's head is supported entirely by the hand of an assistant seated on the right side of the patient. The assistant is provided with a footstool; his right hand, supported by his elbow resting on his knees, should hold

the patient's jaws as shown in *Fig* 1033 while his left hand supports the occiput and thereby control the movements of the head as desired by the operator If possible the operating room should be darkened A gauze swab covers the upper front teeth, the laryngoscope being held in the left hand To prevent the tongue from interfering with the view the instrument should be inserted into the right side of the mouth and as the posterior third of the tongue is reached the tip of the instrument is turned towards the middle line thus bringing the epiglottis into view Avoid inserting the laryngoscope in the centre of the mouth as this procedure is liable to damage the incisor teeth. After the epiglottis has been identified, the tip is passed beneath it and it is lifted forward by tilting the laryngoscope the instrument is then moved into the middle line Great care must be taken not to use the upper teeth as a fulcrum. It is at this stage that the patient may begin to gag If so, a small gauze square soaked in 10 per cent cocaine can be applied to the area by means of alligator forceps. Suction if necessary should be used to remove mucus or blood. During the procedure the right hand is free and should the foreign body be seen it can be grasped with laryngeal forceps and removed. If the foreign bodies are very sharp, take care not to damage the posterior pharyngeal wall or the epiglottis. An open safety pin with its point cephalad will need a special instrument (*see Fig* 1041 p 737) Advancing points perforate trailing points do not

Fig 1033.—Chevalier Jackson's position.

Difficulties.—

1 Failure to recognize the usual landmarks, due to inexperience or to the assistant omitting to keep the head in the middle line.

2. Failure to expose and raise the epiglottis, due to passing the instrument too hastily and exposing the hypopharynx.

3. Overextending the patient's head renders the procedure very difficult. A good assistant will manipulate the head correctly

Bronchoscopy.—

Route.—The question arises whether to pass a bronchoscope via the mouth (upper bronchoscopy) or through a tracheostomy wound (lower bronchoscopy) (*Fig* 1034). Unquestionably the natural passage should be selected unless :—

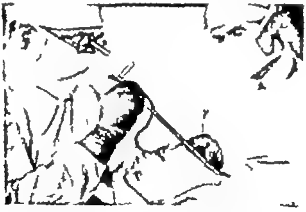

Fig 1034.—Lower bronchoscopy

1 Tracheostomy has been performed already

2. When, owing to respiratory distress, the patient will not tolerate local anæsthesia and a general anæsthetic is inadvisable

3. In a young child when the operator is inexperienced or is unable to procure in time a sufficiently small bronchoscope

For lower bronchoscopy the only anæsthetic that is necessary is to introduce 10 drops of 10 per cent cocaine into the trachea for an adult, and then wait 5 minutes. The tracheostomy tube is removed and the bronchoscope is inserted.

The much more exacting technique of upper bronchoscopy will now be described in greater detail.

Instruments.—Remember that the lumen of the trachea varies with age consequently a bronchoscope (*Fig* 1035) of suitable size must be selected.

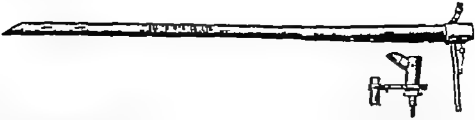

Fig 1035.—Bronchoscope of Negus type. The slits are to allow the entry of air (or the administration of oxygen) into the secondary bronchi. They are also valuable f r facilitating the aspiration of mucus.

SIZE OF BRONCHOSCOPE IN RELATION TO AGE OF PATIENT

AGE IN YEARS	LUMEN OF TRACHEA	BRONCHOSCOPE	
		Lumen	*Length*
	mm.	mm.	cm.
At birth	8	—	—
1	5	4	30
3	[illegible]	6	35
7	9	7†	40
14	14	9‡	40

For upper bronchoscopy in lower broncho-scopy a tube of half the length will suffice
† Also for smaller bronchi of adults.
‡ Standard tube fo adults.

All the lights and junctions must be tested carefully before starting the procedure and a supply of new bulbs should be at hand. With the aid of a closed hand into which the bronchoscope is inserted in a darkened room, a fair idea of the degree of light necessary will be obtained. The bronchoscope should have its source of light at the distal end and

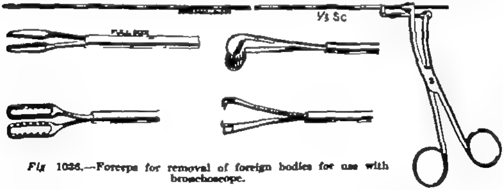

Fig 1036.—Forceps for removal of foreign bodies for use with bronchoscope.

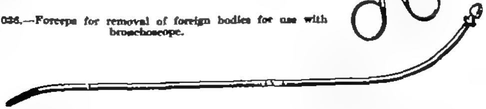

Fig 1037.—Negus's bronchoscopic aspirating tube with flexible gum-elastic end.

all instruments should have their distal ends pierced with a number of holes so that quiet respiration can be carried on. A variety of long forceps are obtained, taking care that their ends project beyond the bronchoscope when they are inserted through it (*Fig* 1036). A Negus's suction tube (*Fig* 1037) which can be attached to a suction pump, is a great help.

Anatomical Data.—The trachea commences at the lower margin of the cricoid cartilage (opposite the inferior border of the 6th cervical vertebra) and ends opposite the 5th dorsal vertebra (*Fig* 1038). It occupies the medial plane, but owing to pressure of the aorta, deviates slightly to the right at its lower end the cartilaginous rings are deficient posteriorly to allow for aortic pulsation The anterior landmark of the bifurcation of the trachea is roughly the 2nd right chondrosternal articulation. The right bronchus represents the continuation of the trachea, the left being merely a large off-shoot. Owing to its slightly

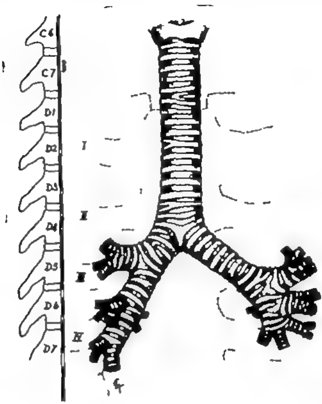

Fig. 1038.—The trachea and bronchi in the adult male showing surface markings with corresponding spinal levels. Scale of centimetres.

larger size, and especially to its more vertical direction, the right bronchus is entered by an inhaled foreign body three times as often as the left. When the neck is long the cervical portion of the trachea is likely to be correspondingly longer and vice versa. In children the whole trachea is somewhat higher both ends at birth being opposite the intervertebral disk next above that of the adult position.

Tracheobronchial measurements —

	Infant	*Child*	*Male Adult*	*Female Adult*
1. Distance from teeth to trachea	9·0 cm.	10·0 cm.	15 0 cm.	13 0 cm.
2. Length of trachea	4 0 cm.	6·0 cm.	12 0 cm.	10·0 cm.
3. Length of right bronchus	1 5 cm.	2 0 cm.	2 5 cm.	2 5 cm.
4. Length of left bronchus	2 5 cm.	3·0 cm.	5·0 cm.	5·0 cm.
5. Internal diameter of trachea	6 7 mm.	8–10 mm.	14–20 mm.	12–16 mm.

(*Chevalier Jackson*)

Premedication —Morphine should be withheld, because it reduces the cough reflex pethidine is substituted. Atropine gr $\frac{1}{100}$ is given to diminish bronchorrhœa

Anæsthesia —Except in children, bronchoscopy can be performed under local anæsthesia, the initial steps being precisely the same as those described for indirect laryngoscopy When the trachea is reached with the bronchoscope long swab-holders armed with small squares of gauze dipped in 10 per cent cocaine are passed down the tube in order to anæsthetize the trachea and bronchi. When a skilled anæsthetist is available a general anæsthetic can be substituted. It consists of intravenous thiopentone, a relaxant such as scoline, and oxygen administration through the bronchoscope.

Passage of the Bronchoscope.—The procedure is carried out in a darkened room with the patient in the same position and with the head held in the same way as for direct laryngoscopy. It is a useful addition to provide a nurse with a good flash-lamp so that the instruments on the trolley can be identified from time to time. The assistant is instructed to hold the head in the middle line in the beginning, but later should be ready to rotate it into any position that is necessary; he is also responsible for checking the pulse-rate.

First of all direct laryngoscopy is carried out, and, if necessary at this stage, a few drops of 10 per cent cocaine are instilled into the trachea with a long syringe. With the laryngo-

Fig. 1039.—Passing the bronchoscope through the vocal cords.

scope held in the left hand, the bronchoscope is taken in the right hand and passed through the vocal cords (*Fig.* 1039); the laryngoscope acts as a retractor and greatly facilitates the manœuvres. Take care that the base of the tongue and the epiglottis are lifted up with the blade of the laryngoscope, and that the teeth are not used as a fulcrum. If the bronchoscope is passed direct it should be inserted at one side of the patient's mouth and the epiglottis is raised in the same way as with a laryngoscope. If the larynx of the patient is in spasm it will be necessary to wait for a few moments in order that the vocal cords can

Fig. 1040.—Endoscopic appearances of bronchi (enlarged). A, Left bronchus; B, Carina; C, Right bronchus. *a*, Eparterial bronchus; *b*, Middle-lobe bronchus; *c*, Apical bronchus of the lower lobe; *d*, Main lower-lobe bronchus; *a'*, Superior bronchus of the lingula; *b'*, Ventral upper lobe bronchus.

be identified. If the operator cannot see the vocal cords the wisest thing is to withdraw the instrument until a recognizable landmark is reached and then to proceed again. Once the vocal cords have been visualized, the tip of the bronchoscope is insinuated between them, with the bevelled portion of the tube pressed against the left cord. The bronchoscope will then slip through the glottic chink. No force must be used, the bronchoscope being held between the fingers and thumb only, and never grasped firmly in the hand. The bifurcation is the first intra-tracheal landmark; when it is seen the assistant is instructed to rotate the patient's head to the left so that the right bronchus can be entered, remembering that it is a continuation of the trachea (*Fig.* 1040).

Not far from the commencement of the right bronchus the eparterial bronchus will be encountered. Farther on, the bronchus divides into three branches. If necessary a sucker can be used to remove any debris present so that the whole area can be examined carefully. If a foreign body is seen, it is grasped in the appropriate forceps and withdrawn, together with the bronchoscope. When the left bronchus is to be examined the bronchoscope is withdrawn into the trachea and the head is turned well to the right and the left bronchus is entered.

Grasping the foreign body. Vegetable substances tend to break up when grasped by forceps; small pieces can be removed with the aid of a sucker. An open safety pin with its point upwards can be removed by a special instrument or by adapting a piece of fairly rigid silver wire (*Fig.* 1041).

Difficulties and Dangers.—Difficulty may be experienced in visualizing the larynx because of failure of allnement. The correct position is flexion of the cervical vertebral joints and extension of the atlanto-occipital joint. Subjects who fail to relax or have short thick necks have difficulty in adopting this position. Another fault is lateral flexion of the head or neck. The oral orifice of other subjects is restricted by protruding teeth, or

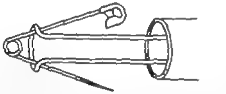

Fig. 1041.—Method of closing an open safety-pin using an improvised piece of rigid wire bent as shown. To close the safety-pin, its spring is grasped with œsophageal forceps, and pushed distally.

by limited movement of the lower jaw. The endoscopy instrument can usually be passed provided the patient is relaxed, and the larynx is anæsthetized fully. It is in difficult cases that general anæsthesia with a muscle relaxant is so helpful.

The great danger in passing any rigid endoscopic instrument is that of damaging the tissues with the tip. In the case of the bronchoscope the vocal cords may be torn, the arytenoid cartilage dislocated, or the trachea itself may be lacerated, causing mediastinitis. All movements should be gentle but firm, and if the procedure is carried out under local anæsthesia the patient must be imbued with confidence. Should he start to struggle the bronchoscope must be removed immediately. The tip of the instrument is advanced only if the operator can see where it is going. *The instrument must on no account be advanced blindly into a pool of secretions.* (All secretion must be removed in order to keep the field clear.) The arch of the aorta, passing behind the trachea just above the bifurcation, comes in direct contact with the posterior wall of the trachea. The posterior tracheal wall has no supporting cartilage, so particular care is needed at this point, especially when removing sharp foreign bodies.

When an impacted foreign body in a bronchus of a child is sharp and gentle attempts at extraction are unsuccessful, the operator should pause and consider whether an open operation of bronchotomy or lobectomy would not be safer than persisting with attempts at endoscopical removal.

A child with a screw in a bronchus, where endoscopical attempts at removal were protracted, and consequently further attempts were postponed until the next day, died during the night from drowning in its own blood. Early resort to bronchotomy would have averted this disaster.

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CHAPTER LXVII

THE SPINE

MENINGOCELE

When confronted with a baby with a congenital cystic translucent swelling in the middle line of its neck or back, the surgeon must ask himself two questions —

1. Is the condition a meningocele or a meningomyelocele? (as diagnosed on clinical grounds).

2. In the former case, is an emergency operation imperative?

1 When there are no apparent neurological signs, the condition is clinically a meningocele and, from the viewpoint of treatment minor signs of neural involvement permit the case to be categorized under this heading Paralysis and gross deformities of the legs and urinary *and anal incontinence are proof that the swelling is a meningomyelocele* and not only the spinal nerve-roots, but a portion of the spinal cord may be present in the sac. These can often be demonstrated as dark shadows on transillumination.

2. If the sac of a spinal meningocele is covered by a very thin membrane or by attenuated skin, a slight injury or even rubbing of the bedclothes, will rupture it (*Fig* 1042). Consequently urgent operation is required.

Fig 1042 —Meningocele which burst. The child died of meningitis forty-eight hours later

In the presence of a meningomyelocele with gross neurological complications, irrespective of the condition of its covering the operation in unpractised hands may lead to disaster and even when performed by one with considerable experience the disability may be so gross that preservation of life by operation often proves more of a curse than a blessing Consequently the presence of a meningomyelocele with gross neurological complications is a contra indication to emergency operation, and if possible the decision as to whether or not to operate should be left to a neurosurgeon or a pædiatric surgeon.

Excision of a Meningocele.—In a very young baby the operation can be performed under local anæsthesia (1 per cent procaine *not* xylocaine). It is important to conserve every drop of blood (the use of diathermy is very helpful), as babies stand blood loss very badly

The patient is placed in the face-downwards, head-low position. Whether the meningocele is in the cervical region or as is more usual, in the lumbar region (*Figs*. 1042, 1043), the principle of the operation is the same An elliptical transverse incision encircling about two-thirds of the swelling (*Fig* 1044), unless more must be included because of absence or unhealthiness of the skin overlying the swelling, is the incision of choice Occasionally owing to the shape of the sac or on account of ulcerated areas, a longitudinal ellipse is required With a fresh scalpel the operation proceeds in a manner comparable to that for an umbilical hernia. When the neck of the sac has been reached it may be found

distinctly pedunculated. Should the neck be no larger than a pencil, it can be ligated without opening it.

Should the neck incline to the sessile type (*Fig* 1043) it is probable that nerve-roots are attached within it. It is, in fact, a meningomyelocele. There is usually no difficulty in recognizing nerve-roots before the sac is opened for they can be seen through the semi-transparent membrane. Whether the sac is sessile or has a comparatively broad neck, the subsequent steps of the operation are almost identical.

Fig. 1043.—Meningomyelocele of the sessile type. It was removed successfully.

Fig 1044.—Relation of the skin incision to the swelling.

The sac is opened some little distance above the bony defect or, if such is present, above the neck. Cerebrospinal fluid runs out, and the distended sac then collapses. While this is occurring the major part of the sac is snipped away deftly avoiding spinal roots and constantly being mindful to leave sufficient fringe for the cut edges to be coapted without tension. Quickly the dural edges are stitched together with a continuous fine thread suture, to avoid undue escape of cerebrospinal fluid.

If the baby's general condition permits, a simple plastic operation may be performed. The sheath of the erector spinæ on each side is incised and the two medial cut edges are brought together (*Fig* 1045). The skin is now united. By undercutting it is usually possible to bridge the gap. Occasionally it may be necessary to relieve tension by making a transverse cut about 2 in. (5 cm.) distance above the skin wound. On no account should this cut be made below where it will be in juxtaposition to the napkins.

When the sac has a narrow neck, any plastic procedure to cover the bony defect is probably unnecessary.

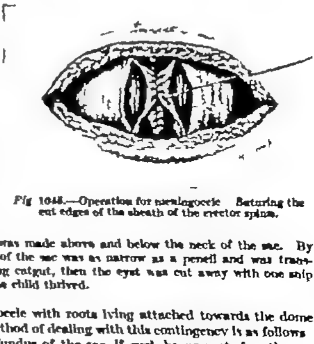

Fig 1045.—Operation for meningocele. Suturing the cut edges of the sheath of the erector spinæ.

A male child was born with a meningocele the size of a Jaffa orange at the occipito-cervical junction. The walls of the sac were so thin that fluid could be seen within. It was obvious that rupture of the cyst was imminent. Operation was undertaken, the babe being fifteen hours old. Anæsthesia was induced with a few drops of chloroform. An elliptical incision was made above and below the neck of the sac. By dissection it could be shown that the neck of the sac was as narrow as a pencil and was transparent. This stalk was ligatured with strong catgut, then the cyst was cut away with one snip of the scissors, and the skin was closed. The child thrived.

Difficulties.—Should a meningomyelocele with roots lying attached towards the dome of the sac be encountered the simplest method of dealing with this contingency is as follows: remove the ellipse of skin covering the fundus of the sac. If such be present, free the sac from surrounding tissues, and then puncture the sac and let it collapse into the spinal canal as far as it will. Avoiding roots, plicate the sac with unabsorbable sutures, so that it cannot unfold, and complete the operation as described already.

In all cases, at the completion of the operation the wound is covered, preferably with gutta percha or polythene sheeting followed by several layers of gauze held in place by flexible adhesive plaster.

After treatment.—If the child is shocked an oxygen tent or incubator may be required. In any case fluid replacement and subsequently the maintenance of fluid balance is of prime importance. A course of penicillin is given until the wound has healed firmly and the danger of leakage has passed.

Late Results.—For five years, at increasing intervals, the child should be watched for the development of hydrocephalus which, if it occurs, is likely to be due to the Arnold-Chiari malformation. This consists of displacement of the hind-brain (rhombencephalon) and herniation into the spinal canal of the cerebellar tonsils, which obstruct the free circulation of cerebrospinal fluid. *Taken in time the Arnold-Chiari malformation can occasionally be remedied by a neurosurgical operation.*

INJURIES OF THE SPINE

A man has fallen and is believed to have broken his back. If the body of a dorsal or lumbar vertebra is fractured, it is of paramount importance to avoid flexion of the spine for flexion increases the angular deformity and may cause untold damage to the cord. Therefore first aid workers should be taught that a patient with an injury to the spine must be carried *face downwards.*

On the gold mines of the Witwatersrand, where the injury is common, the instructions are that if a patient is found lying on his face he is put on the stretcher face downwards, with one blanket under the shoulders and one under the hips, to maintain hyperextension. If he is found on his side he is turned on to his face or back, whichever gives less disturbance. If he is found lying on his back he is lifted in the same position on to the stretcher, care being taken to ensure hyperextension of the spine during the lifting. On the stretcher hyperextension is maintained by a folded blanket arranged to support the fracture.

These instructions do not apply to the cervical region. When a fracture of the cervical spine is suspected, the patient should be transported (and nursed) in a neutral position (i.e. midway between extension and flexion).

On hearing that there is a case of spinal injury on the way, the nursing sister will, if possible, have prepared a bed with a sorbo-rubber mattress. The stretcher is carried to the foot of the bed and six assistants are summoned. The first pair grasp the patient's shoulders,

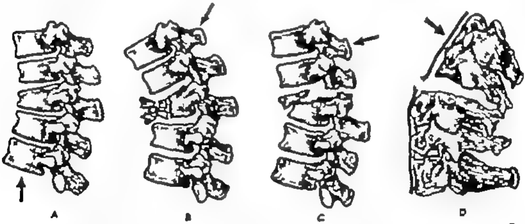

Fig. 1046.—A, Crush fracture; B, Comminuted fracture; C, Fracture-dislocation; D, Hyperextension rupture of the anterior longitudinal ligament. (A, B, C, *after Sir Reginald Watson-Jones.*)

two more insinuate their arms beneath the pelvis, while the remaining two take each one thigh. At the given command the bearers gently raise their burden, move together from the foot towards the head of the bed, upon which they lower the patient face downwards. The head is turned and laid on a small soft pillow. When the injury is in the cervical region the surgeon himself takes charge of the head while the patient is being lowered on to the bed; on this occasion the face-downward position is not employed—the patient is laid upon his back. A nest of cotton wool is insinuated behind the neck. Finally, his head is placed between sandbags.

In all cases the clothing is cut off. Clinical and radiological examinations are deferred until shock has been treated.

Fractured spine is divided into four main varieties (*Fig* 1040). (1) Compression (crush) fracture (2) Comminuted fracture by acute angulation (3) Fracture-dislocation which is often accompanied by gross injury of the spinal cord (4) Hyperextension injury with rupture of the anterior longitudinal ligament (cervical region only).

THE SPINAL CORD IS NOT INJURED

It should be especially noted that the treatment of spinal column injuries without cord or cauda equina involvement is diametrically opposite to that used in the presence of such

Fig 1047 —Hyperextension of the spine secured and maintained by two tables of different height. (*E. T. Cato—by kind permission of the Australian and New Zealand Journal of Surgery*)

involvement. If there are *any* signs of a neurological lesion, manipulation and/or the application of a plaster-of Paris jacket should *never* be carried out.

On the other hand if the physical signs and subsequent radiograph show that there is a crush fracture of the body of a dorsal (see *Fig* 1046) or a lumbar vertebra without interlocking we cannot do better than apply a plaster jacket with the spinal column in a hyperextended position.

Application of a Plaster Jacket.—The position required can be maintained more easily by the conscious patient. A suitable dose of morphine is given, and local anæsthetic is injected into the musculature in the region of the fracture Two tables are arranged with a space between slightly greater than the length of the patient's trunk. For the forward table it is advisable to use an operating table so that the hyperextension can be obtained gradually by raising the table after the patient is in position. Throughout treatment flexion of the spine must be avoided. The patient is lifted *face downwards* on to the lower table, and a double layer of stockinette is pulled over the trunk and stitched over the shoulders and beneath the perineum. The spinous processes and the iliac crests are further protected by small pads of adhesive felt or sorbo-sponge but it is essential that the plaster should fit very closely bulky padding with wool or felt is to be avoided.

Fig 1048.—Plaster jacket completed.

The patient is now assisted into such a position that he is gripping the edge of the higher table with his abducted arms (*Fig* 1047). The plaster is now applied and is moulded to the curve of the spine sacrum, and iliac crests. It should extend up to the neck, and although it may be cut out below each axilla to allow free use of the arms, *none must* be removed from the front of the thorax. It extends over the sacrum and down to the level of the trochanters and symphysis pubis, with a small area cut out over each groin to allow flexion of the hip (*Fig* 1048).

After-treatment.—The patient is encouraged to move about in bed, and is turned frequently to avoid pulmonary congestion. Massage and movements are commenced at an early date After ten days the patient may get up, and soon afterwards he is encouraged

to walk. Protection of the vertebra is necessary for four months. If exercises are practised constantly the plaster may be retained throughout this period.

An excellent alternative method of maintaining hyperextension during the application of the plaster is shown in *Fig* 1049

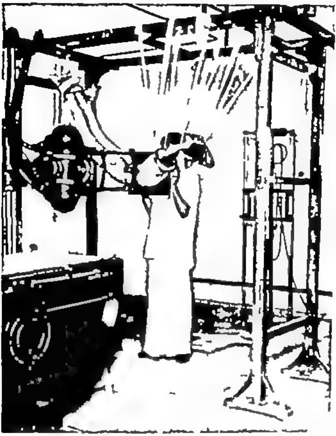

Fig 1049 — A method of slinging the patient in order to obtain hyperextension of the spine. (*Mr R. F W K Allen, Bulawayo, Southern Rhodesia.*)

FRACTURE-DISLOCATION OF A LUMBAR VERTEBRA WITH INTERLOCKING

It is unsafe to treat this type of injury by the method described above Paraplegia is liable to be produced in cases where previously there was no involvement of the cord or its roots. The fracture-dislocation must be reduced by open operation before the plaster jacket is applied.

FRACTURE-DISLOCATION OF THE CERVICAL SPINE

Fracture-dislocation of the cervical spine can occur with or without involvement of the cord. In contradistinction to similar injuries of the dorsal and lumbar spines, the initial treatment of both these varieties of cervical injuries is identical. Here manual and other forms of reduction have been known to produce a quadriplegia, and such a risk is unjustifiable On the other hand gradual reduction by skeletal traction is efficient and entirely safe. This principle was described originally by W E. Gallie, and a modification of his method is recommended.

Application of Skull Traction.—For this purpose Blackburn's method of applying traction to the skull is to be preferred. Under local anæsthesia, two small incisions are made one above each pinna, just below the most prominent part of the parietal bone With a special small trephine (*Fig* 1050 inset) a hole is made as far as the inner table (but not through it), and a disk of bone is removed. Blackburn's skull traction calliper (*Fig* 1050) is now applied. The principle of Crutchfield's pattern of skull calliper is similar but in order to accommodate the teeth of the calliper a special bradawl is used to perforate

the outer table. W. E. Gallie used an ice-tong calliper which unfortunately tends to cut out. A good alternative to a skull traction calliper is to employ the Camp cervical head halter[1] (*Fig.* 1031). As a very last resort, when a modern traction apparatus is not available Crile's skull halter (*Fig.* 1032) which can be made from webbing or sail-cloth, can be employed. The application of a skull traction calliper can be performed in bed on a trolley or on any table. A cord is attached to the calliper and passed over a pulley fixed to the head of the bed. The weights (15–25 lb.) (6.8–11.32 kg.) are suspended from the cord and the head of the bed is raised 12 in. (30 cm.) on blocks.

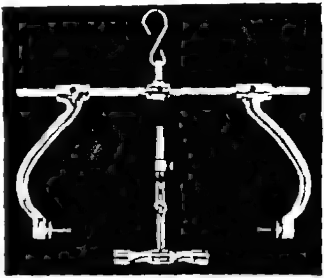

Fig. 1030.—Blackburn's skull traction calliper with small skull trephine.

Subsequent Management.—When the fracture has been reduced (as evidenced by portable radiography) the weights are adjusted so that only sufficient are left to maintain the reduction. After two or three days the patient is hardly aware of the calliper. He is comfortable, respirations are not impeded by a plaster cast, and the whole of his skin is available for nursing care. With ingenuity in arranging the pillows, he can be turned from side to side or even on to his face, for attention to his back. In the case of involvement of the cord, care of the urinary tract is added to the other considerations, and to prevent pressure sores the care of the skin must be unremitting. When the cervical cord is injured respirations become very much impaired. If the lesion is *complete* it is arguable whether or not much effort should be made to preserve life. With an incomplete lesion, everything possible should be done to maintain oxygenation. The calliper is retained until such time as radiology indicates union of the fracture (8–12 weeks).

Fig. 1031.—The Camp angle-flexion cervical head halter. The angle recommended for the traction is 25 with a weight of 8 lb. (3.6 kg.) or more if required.

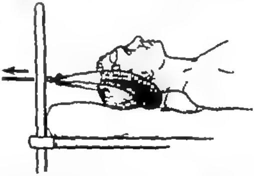

Fig. 1032.—Crile's home-made harness for exerting traction on the cervical vertebræ. (*After S. A. S. Malkin.*)

Dislocation with locking of the articular processes may resist this method of reduction. This type of dislocation is diagnosed radiographically in the first instance. If, during the first 24 hours after the application of the calliper the processes are still locked, an open reduction should be undertaken forthwith.

Open Reduction consists of making a midline incision, exposing the laminæ of the affected and adjacent vertebræ and removing a minimum amount of bone from the articular process on one or both sides of the upper vertebra taking part in the dislocation, with traction maintained during and after operation. Occasionally gentle leverage into a normal position is necessary.

[1] S. H. Camp & Co. Ltd., 19 Hanover Square, London, W. 1.

A special and extremely rare injury in the cervical region is that in which the arch of the vertebra is fractured and displaced beneath the arch of the vertebra above the fracture and compresses the cord. Urgent laminectomy is essential.

Cervical Hyperextension Injuries.—In recent years, extension fractures of the cervical spine have been recorded, often following falls upon the face, or frontal head injury in traffic accidents. In the presence of cervical spondylosis, hyperextension of the cervical spine sometimes causes a spinal cord injury without evidence of a fracture or with a fracture without displacement. In these cases lumbar puncture with careful manometry should always be performed to exclude a spinal block. The presence of a spinal block can be shown by Queckenstedt's test employing a spinal manometer (*Fig.* 1090, p. 791).

Queckenstedt's Test.—The rise and fall of the lumbar cerebrospinal pressure is charted during compression and release of the internal jugular veins. In normal circumstances compression of the veins of the neck causes a steep rise in cerebrospinal fluid pressure and a somewhat slower passive fall. The first effect of obstruction is to prolong the passive fall. As the obstruction becomes greater there is a correspondingly slighter rise, and finally, when the block is complete, compression of the jugular veins causes no rise at all.

If there is no block, the patient is treated by the application of a light plaster, plastic, or leather cervical collar applied in the neutral, or even the very slightly flexed, position (Taylor and Blackwood), together with early mobilization.

In the presence of a spinal block, which may be due to a massive disk protrusion, emergency investigations and possibly laminectomy with removal of the prolapsed disk, should be carried out. If possible the services of a neurosurgeon are most desirable.

FRACTURE-DISLOCATION OF DORSAL AND DORSO-LUMBAR SPINE WITH CORD INVOLVEMENT

It is stressed here that the treatment of the bony lesion is secondary to the management of the all-important neurological lesion. A. S. Kerr of Liverpool teaches that the line of treatment adopted depends entirely upon the answer to the vital question "Is the lesion of the cord complete or incomplete?" For practical purposes heeding the dogmata 'stage of spinal shock' and 'stage of flaccid paralysis' which made impossible the early differentiation between a partial and complete lesion has now been abandoned. In Kerr's vast experience, a lesion which shortly after the injury is *complete* on meticulous neurological examination and remains so for 48 hours, is, in fact, anatomically complete and no useful neurological recovery will occur. He believes that the only vital problem in these cases is full rehabilitation into the life of a paraplegic. The fracture-dislocation is disregarded completely and the patient is mobilized out of bed from the third day onwards. This revolutionary management is paying most handsome dividends to the patient. Bed-sores and urinary infection, the two nightmares of the paraplegic, are reduced to a minimum; the patient learns to fend for himself in a new existence, instead of brooding for weeks and months as a bed-ridden invalid. The work of L. Guttman, who has shown what can be done by a well-planned scheme of rehabilitation, has altered the attitude of the medical profession and the lives of these unfortunate patients.

The Neurological Lesion is Incomplete.—There is no uniformity of views concerning the treatment of these cases. In this work it is recommended that every patient in whom the lesion is incomplete be subjected to radiography and careful manometry as soon as possible.

1. If the fragmentation of the fracture and the degree of dislocation are minor and there is no spinal block, operative treatment should not be undertaken. The patient is nursed on a sorbo-rubber mattress with a small pillow at the level of the fracture, to bring about slight extension of the site of the fracture, whether it be in the dorsal or the dorso-lumbar region. A plaster-of-Paris case is not applied. For attention to his back the patient is rolled on to his side with the utmost care by at least two nurses, who are mindful to ensure that there is no more than the minimum of movement at the site of fracture.

2. In the presence of considerable fragmentation and dislocation, open reduction is performed (see p. 765). The fracture in these cases being unstable, some form of immobilization is necessary. Since plaster-of-Paris is not permissible, internal fixation is required. A metal plate on either side of the spinous processes, bolted together through a spinous process above and below the fracture-dislocation, is a good method of fixation. Nursing after the operation follows that described under (1).

3. In the event of a spinal block being present, laminectomy must be performed.

FRACTURE-DISLOCATION OF THE LUMBAR SPINE

(*a*) **Fracture-dislocation with a Complete Cauda Equina Lesion** is very rare. The correct alinement of the spine is here more important than in the dorsal region. The treatment is the same as in (*b*)

(*b*) **Fracture-dislocation with an Incomplete Lesion of the Cauda Equina** without spinal block requires open reduction with or without internal fixation. The latter depends on the degree of instability of the bony lesion. If a spinal block is present, laminectomy is required also Plaster-of Paris is not permissible

(*c*) **Fracture-dislocation without Neurological Involvement** (a rather rare condition) necessitates open reduction, but the application of plaster-of Paris is allowed, if so desired

Cauda Equina Lesions without Dislocation.—Lesions of the cauda equina, complete or incomplete, without radiological evidence of fracture-dislocation, or in the presence of a simple compression fracture of the body necessitate urgent laminectomy In these circumstances a massive disk protrusion may have occurred. A spinal block is usually present, but if either of the lower two disks is involved manometry can be misleading because standard lumbar puncture is performed above the level of the lesion. In the presence of a cauda equina lesion without dislocation there should be no delay in exposing the prolapsed disk by laminectomy and removing the disk completely The level of the block can often be confirmed by myelography and this investigation should be carried out whenever possible

INDICATIONS FOR URGENT LAMINECTOMY IN TRAUMA

1 Penetrating wound.

2. Compression of the cord by a fractured arch of a vertebra (very rare in the cervical region).

3. Dorsal or lumbar fracture-dislocation with an incomplete neurological lesion in the presence of a spinal block.

4 Spinal block following major or minor trauma without radiological evidence of a dislocation, but in the presence of some degree of neurological involvement. This may be caused by a massive protrusion of a disk. Such a condition is rare in the cervical region, but is more common in the lumbar region. The importance of this lesion has been stressed recently by H Jennett.

LAMINECTOMY

When the operation is to be performed on the dorsal region the patient lies prone with a sandbag under the epigastrium. If the exposure is to be made in the lumbar region sandbags are so arranged under the anterior superior iliac spines as to obliterate the lumbar curve as much as possible and at the same time keep the abdomen off the table (*Fig* 1033)

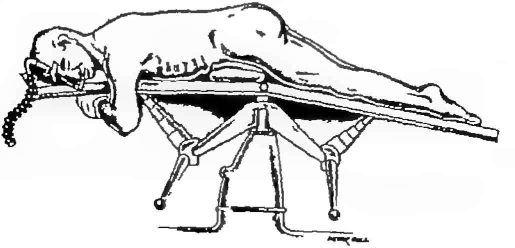

Fig 1033.—Position for lumbar laminectomy Incidentally by keeping the abdomen off the table venous congestion is reduced.

It must be recalled that there is disparity in the length of the spinal cord and the *vertebral column*. *Therefore in planning the operation of laminectomy in the cervical* region the lesion lies one vertebra above the level of localization; in the upper dorsal region this is increased to two, and in the lower dorsal and lumbar regions to three. In counting the vertebræ by palpation, owing to the downward imbrication of the spinous processes, in the dorsal and lumbar regions allow one vertebra extra, making the last two figures referred to three and four respectively.

Make a longitudinal median incision 8 in. (20 cm.) long (*Fig.* 1054) with its centre over the vertebra which is damaged. Reflect the skin on either side and fix towels to the skin edges. Deepen the incision until the spinous processes are reached. A bold cut is now made through the aponeurosis and muscles just to one side of the spinous processes; it is carried right down to the laminæ. Considerable hæmorrhage occurs, which is arrested by plugging the space firmly with gauze. After a few moments the gauze is removed, and using a broad chisel after the manner of a periosteal elevator the muscular mass is elevated

Fig. 1054.—An incision for laminectomy.

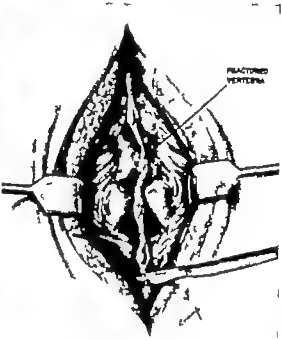

Fig. 1055.—Laminectomy. The fractured vertebra and two vertebræ above and two below have been exposed. The interspinous ligament between V5 and V6 is being divided.

from the laminæ. This cavity is again plugged with gauze while a similar procedure is carried out on the opposite side. By utilizing the method of gauze pressure on each side *the number of bleeding points that require ligation or diathermizing* is considerably reduced. As soon as hæmostasis is satisfactory the muscular masses are retracted strongly, preferably with a mechanical retractor, thus revealing the spinous processes. Five spinous processes should be displayed, two above and two below the injured vertebra. For convenience these vertebræ will be referred to as V1, V2, V3, V4, and V5, V3 being the injured vertebra. Divide the lowest interspinous ligament (*Fig.* 1055). With bone-cutting forceps remove cleanly the lower two spinous processes as close to the laminæ as possible. With the knife divide the interspinous ligament between V4 and V3, thus removing in one piece the two lowermost spinous processes below the lesion. Pass to the upper end of the wound and remove the spinous processes of V1 and V2 in the same manner. We are ready for the crucial stage of the operation—exposing the dura.

The safest method is to use a Hudson's brace and burr and following an established dictum "always trephine sound bone" apply the burr to the lamina of V5 (*Fig.* 1056). Having entered the extradural space enlarge the opening with nibbling forceps (*Fig.* 1057), first carefully separating the dura from the bone with some flat instruments such as a Horsley's dura mater separator (*Fig.* 1058). To control the bleeding from bone Horsley's

wax has never been bettered. Employing the seeker and then nibbling is a safe but slow method of exposing the dura. A quicker method if suitable instruments are at hand, is to use a narrow bladed bone-cutting forceps, one blade of which is inserted between the under surface of the lamina and the dura. If the latter method is to be used, it is essential to be certain that the dura has been separated from the lamina, and when the blade has been introduced there should be very little pressure on the cord. In this way the lamina is divided on either side as near as possible to the articular processes. By one or other method the laminæ of V4 and V5 have now been removed. The spinous process of V3, the fractured vertebra, is then grasped and gently pulled. It may be found that it is loose and can be removed. If not, its laminæ are divided, as also are those of the remaining V2 and V1. A portion of the dura is now exposed, but there is an overhanging edge of bone on either side. This may be removed by nibbling forceps or Hudson's guillotine forceps, which have been specially designed for this work and are ideal for the purpose. The ligamenta flava beneath the site of each lamina are now seen. The ligamenta flava and the epidural fat are incised in the midline and the ligamenta are removed. The dura is then in full view.

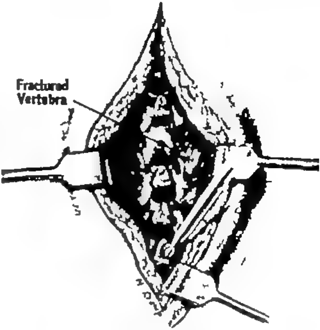

Fig. 1036.—Laminectomy; the burr hole about to be made in the lamina.

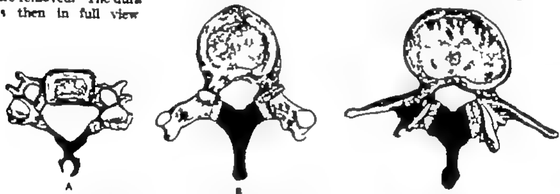

Fig. 1037.—Laminectomy. The dead black and dotted portions indicate the amount of bone to be removed in order to expose the spinal cord adequately. A, Cervical; B, Dorsal; C, Lumbar.

In the case of an *extradural abscess* on no account should the dura be opened. On the other hand, in the case of a *penetrating wound* after displaced pieces of bone or missile, if present, have been removed, infection or no infection, the dura must be opened at the site of the lesion.

In cases of *closed injury where blood is seen beneath the dura*, the dura should also be opened well away from the site of the lesion in the following way: transfix a point of the dura with a stitch on an atraumatic needle and by its agency elevate this membrane and incise it. A safe method of doing this is to stroke the dura three or four times in a longitudinal direction with the point of a large straight cutting needle. The opening is enlarged with scissors. The appearance of

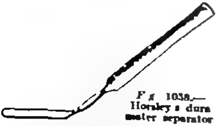

Fig. 1038.—Horsley's dura mater separator.

the crushed or contused cord varies. Sometimes as soon as the dural sac is opened, a transverse discoloured depression is noted At others, the cord in the vicinity of the fracture is œdematous.

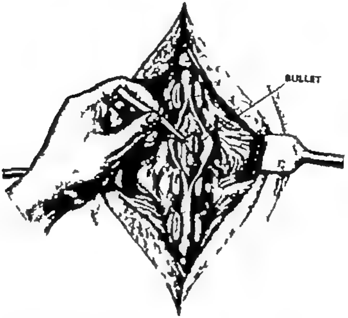

Fig 1059 —Exerting traction upon divided dental ligament in order to rotate the cord.

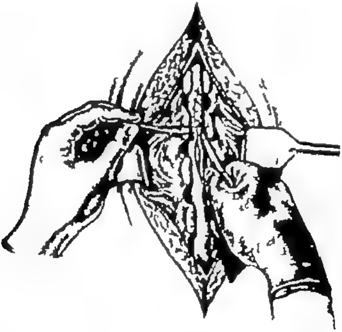

Fig 1060.—Laminectomy Closure of the d ra

No attempt should be made to remove broken-down cord tissue. To suture a divided or partially divided cord is worse than useless, for regeneration is impossible

On the other hand the anterior roots (but not the posterior roots) of the cauda equina do regenerate. To identify these slender roots requires considerable skill but if the condition of the patient is satisfactory an attempt should be made to unite them after the manner of nerve suture.

Posterior roots damaged at the site of a lesion of the spinal cord should be severed to protect the patient from subsequent root pain, but not more than two roots should be divided and never any roots of the cauda equina.

If it is necessary to rotate the cord so as to inspect the anterior surface, as may be the case in the removal of a foreign body a dentate ligament is picked up with forceps, and with fine scissors its attachment to the dura is severed. By exerting traction on this slip the cord can be rotated delicately (*Fig* 1059) with the least possible disturbance.

Reconstruction.—Except in the presence of sepsis the dura is closed completely by a fine running suture (*Fig* 1060). The muscles are then brought together by strong interrupted catgut stitches. Lastly the fascia is united and the skin closed.

COMPLICATIONS OF SPINAL INJURIES

Retention of Urine.—*See* p 651

Paralytic Ileus is a distressing and sometimes fatal early complication of spinal injury In such cases dilated coils of intestine are only too obvious in the radiograph taken to reveal the fracture. Gastro-intestinal aspiration should be commenced as soon as the condition is strongly suspected. For other details in management see Chapter XL.

Prevention of Bed-sores.—It is most important that the bed sheets be kept free from wrinkles or bread-crumbs hot water bottles should not be used, for severe bottle burns readily develop in paralysed limbs. Attention to the skin is of great importance After the bowels have acted is a good time to treat the back with borax in spirit or a 1 per cent solution of formaldehyde both these solutions tend to toughen the skin and are antiseptic. In paraplegics the skin should receive attention at least every four hours more ideally every two hours. The prevention of bed-sores is discussed on p 153. The nursing of spinal cases is greatly facilitated by the use of the Emessay turning bed frame.[1] The buttocks, heels, malleoli and lower parts of the back are watched by the nurse for redness, at the first sign of which a ring of cotton wool or a ring air-cushion is placed about the area to prevent further pressure.

Prevention of Drop-foot.—Drop-foot can largely be prevented by having the feet kept at right angles with sandbags. An additional sandbag on the outer side of the foot and lower leg overcomes eversion of the limb It is amazing how readily a lateral popliteal neuritis can develop (particularly in an already paralysed leg) from mere pressure of the bed-clothes below the knee if the leg is allowed to assume an everted position. When sand bags are employed the legs must be examined every time the patient is attended to for signs of impending pressure sores. Physiotherapy with full range of passive movements of the limbs should be instituted at least twice daily

ACUTE EXTRADURAL SPINAL ABSCESS

The majority of abscesses in this situation are secondary to a staphylococcal lesion of the skin e.g. a furuncle although occasionally the abscess is the result of osteomyelitis of the spine or elsewhere. Among all the diseases that affect the spinal cord, this condition is one of the greatest urgency Early diagnosis and operation will lead to complete recovery delayed diagnosis and treatment will result in a permanent paraplegia failure to diagnose the condition will result in the death of the patient.

This subject has received rather scanty attention in this country as opposed to the United States, but this has been rectified recently by Hulme and Dott. The illness commences with pyrexia and localized backache, progressing to severe root pains. Early signs of impairment of cord function follow which leads to a complete paraplegia. The crucial diagnostic and prognostic stage is the transition from early cord compression to a complete lesion, and this may take less than 24 hours. That the condition is one of utmost urgency is evident. The operation recommended for this condition is laminectomy (*see* p 703). The dorsal region is the most frequent situation for the abscess, the lumbar region is the next common the condition is rather rare in the cervical region. The space-occupying lesion may consist of fluid pus under tension which, after the overlying bone has been removed, can be evacuated readily It may however consist of a layer of granulation tissue studded with small areas of fluid pus. In such a case the whole of the infected tissue

[1] Medical Supply Association, Lark Royal Road, London, N W 10.

should be excised by sharp dissection. At least two No. 2 rubber catheters are inserted, one at the upper and one at the lower extremity of the abscess cavity for instillation of antibiotics. In addition to the local treatment, systemic antibiotics should be given, appropriate to the type and sensitivity of the organism isolated.

SUDDEN PARAPLEGIA FROM SPINAL METASTASES

Possible causes of spinal metastases are carcinoma of the breast, lung thyroid, prostate, and kidney

Grawitz tumour is notorious for the diversity of its metastatic lesions. Paraplegia of sudden onset is sometimes the sole presenting feature of a renal carcinoma. Since the spinal deposit is not always evident radiologically and as intravenous pyelography is simple, the lesion becomes obvious. When confronted with a case of sudden idiopathic paraplegia, unless the cause can be demonstrated clearly never embark upon any form of active treatment before viewing urograms, a form of investigation that should be carried out without delay this applies even in total absence of urinary symptoms or suggestive abdominal physical signs.

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Revised by C. B. Sedzimir, M.D., F.R.C.S. (Edin.),
Surgeon, Regional Neurosurgical Centre Walton Hospital, Liverpool.

CHAPTER LXIII

THE HEAD

LOCAL ANALGESIA

LOCAL analgesia with 1 per cent procaine is the safest and is perfectly satisfactory for many urgent operations upon the head. If the nerves of the scalp are blocked effectively necessary operative measures in this region can be conducted painlessly for the skull, dura, and the brain are insensitive. True pulling upon the dura gives rise to referred pain, but with due care this can be avoided. One of the many advantages of local analgesia is that it ensures a gentle technique, which, important at all times, is essential in patients still suffering from the effects of cerebrospinal shock. When using local infiltrations for operations on the cranium, we must realize that it is the scalp and nothing but the scalp which must be anæsthetized. As the nerves come from below it is the basal part of the scalp which requires thorough infiltration, and adequate time must be allowed for the procaine to take full effect. To encircle the operative area as shown in *Fig* 1061 meets every requirement. The use of local injections necessitates wide shaving of the operative area, which is all to the good from other points of view There are, of course, a number of instances where common sense dictates that local analgesia will be unsuitable If it is considered that with ordinary premedication the patient is unlikely to remain quiet during the operation, general anæsthesia is advised. Again, from time to time a seemingly quiet patient with a head injury becomes obstreperous, and the local infiltration is insufficient but it can always be supplemented by slowly injected intravenous thiopentone or endotracheal gas-oxygen-trilene anæsthesia. These contingencies are comparatively infrequent.

Fig. 1061 —Infiltrating the scalp with local procaine in a case of a wound of the head.

HÆMATOMA OF THE SCALP

This common complication of head injuries usually calls for no treatment. When large and soft aspiration is occasionally required since even the slightest infection can have serious consequences, the strictest aseptic precautions (under penicillin protection) are necessary before evacuating the blood.

As is now widely appreciated, the firm fibrinous edge of a hæmatoma can mimic a depressed fracture to a nicety Equally important is the fact that a fracture not infrequently coexists with a hæmatoma; hence radiological investigations must support every diagnosis of hæmatoma, no matter how small the swelling might be

OPEN WOUNDS

Never depart from the wise rule that if shock is present it must receive priority in treatment Conversely the sooner a wound of the head is attended to the better There is seldom any need to delay in adequately shaving the scalp and preparing the skin for

these measures can be carried out in bed while awaiting the radiological examination of the skull since all open wounds are potentially infected 500 000 units of penicillin are injected intramuscularly at once

As a rule it is best to shave the head completely [1] When the hair is thick and matted with blood and grit, this is by no means a light undertaking Cut the hair short with scissors, comb it, then scrub it with a sterile nail-brush with soap and water and finally shave it (G F Rowbotham). One per cent cetavlon can be recommended as the soapy solution.

In this section it is proposed to deal with all degrees of open wounds, from a cut head to a wound of the brain, for there is one guiding principle in all these wounds—meticulous wound excision.

Every scalp wound requires skilful attention, for seemingly trivial head wounds sometimes turn out to be associated with major cranial injuries.

The secretary of a football club fell down the station steps, striking the back of his head. He received first aid in the form of stitches to a scalp wound over the occiput, and he was admitted to hospital at 1 a.m. By the following morning he had regained consciousness, but was drowsy At 4.30 p.m. he again lapsed into unconsciousness, which was complicated by fits *on both sides of the body* The spasms began in the feet passed up the legs and were followed by contortions of the face. The pulse was 120 respirations stertorous, and nystagmus marked. The bilateral nature of the fits and the central position of the (sutured) cut had made the diagnosis of injury to the superior longitudinal sinus tolerably certain. A semicircular flap was turned down around the sutured scalp wound. A fissured fracture was seen in the middle line immediately above the torcula. Two trephine holes were made on either side of the middle line and the intervening bridge was removed. Blood could be seen beneath the bulging dura. The dura was opened and a thin film of venous blood was seen flowing over the cerebral hemisphere The hæmorrhage was controlled easily by gauze packing insinuated between the dura and the skull in the middle line The blood was mopped up and an attempt was made to close the dura, which was practically brought together Drainage was provided at the most dependent part of the wound. The next day the patient was conscious. On the eighth day signs of meningitis set in, and lumbar puncture showed purulent cerebrospinal fluid He died on the tenth day

If I had not forgotten that the scalp wound had not been excised, it is improbable that meningitis would have supervened. Packing should not have been used.

CUT HEAD

Excision of the Wound.—Using a sharp-pointed scalpel, excision of the edges of the wound can be quickly and thoroughly yet sparingly performed by employing the following technique after cleansing the parts with dettol the integument is steadied and stretched by two towel clips (*Fig* 1002). Digital pressure prevents excessive blood loss until the epicranial aponeurosis has been picked up in hæmostats and everted over the bleeding vessels (*see Fig* 1003 inset) Hæmostasis is effected by diathermy coagulation, in preference to ligation or undersewing with a ligature on a needle. The hæmostats are left on (*Fig* 1003) until the scalp sutures have been inserted, the hæmostats being removed just before these sutures are tied

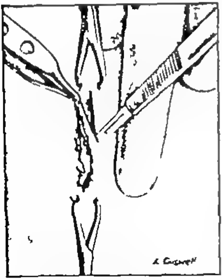

Fig 1002.—A method of excising a wound of the scalp (see text)

A mechanical retractor (mastoid type) is applied and the depths of the wound inspected. Road grit glass, hair and such-like are picked out, and the wound is irrigated with saline All bruised torn, and ragged tissue is snipped away until the whole area presents an indubitably clean-cut appearance The wound is then flooded with penicillin solution, dried, and dusted with sulphanilamide powder and the retractor is removed

[1] P B. Ascroft and R J V Pulvertaft have shown that the most highly infective portions of the hair are the roots to sterilise these deeper parts forms an additional reason for the administration of antibiotics.

Fig. 1063.—Excision of scalp: hæmostats in place and hæmorrhage from lower margin of wound being controlled by digital pressure. (*J. Schorstein.*) *Inset*: Method of applying hæmostats to and everting the epicranial aponeurosis, as opposed to securing individual bleeding vessels.

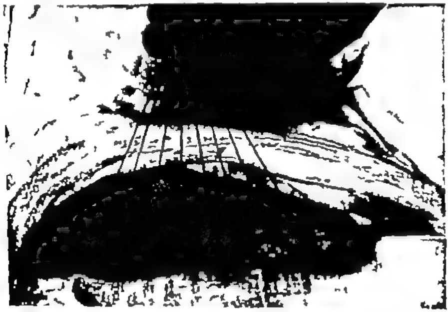

Fig. 1064.—Repair of scalp; galeal sutures inserted. (*J. Schorstein.*) (*Reproduced by permission from the British Journal of Surgery, War Surgery Supplement No. 1.*)

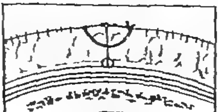

Fig. 1065.—A method of suturing the scalp. The galea is first approximated with fine unabsorbable sutures.

METHODS OF DEALING WITH SCALP WOUNDS WITH LOSS OF SUBSTANCE

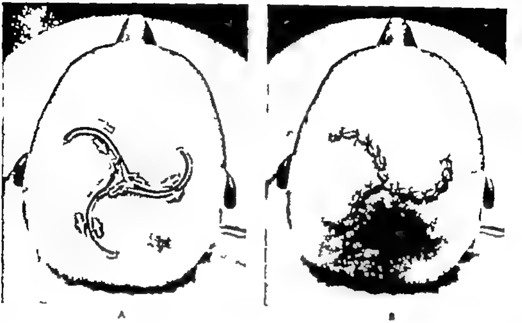

Fig 1066.—A, Isle of Man incisions; B Method of approximating the mobilized flaps.

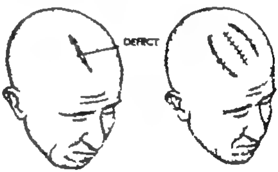

Fig 1067.—Relieving tension by counter-incisions. (*After Rowbotham and H mersley*)

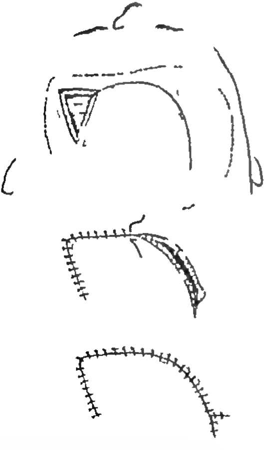

Fig. 1069 The sliding flap f r closure of triangular-shaped scalp defect The dotted line represent area of scalp mobiliz tion. (*J M Small and F A Turner*) (*Reproduced by permission from the British Journal of S rgery Wa Surgery Supplement N 1*)

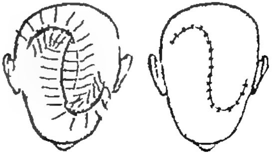

Fig 1068.—The reversed S incision. (*After I L. Lockwood.*)

Suturing the Scalp.—The best method is to employ a series of interrupted fine thread or cotton sutures to approximate the epicranial aponeurosis. These sutures, introduced on a curved cutting needle, reduce tension on the skin and prevent hæmatoma formation the ends are left long until all have been inserted, for traction on these sutures materially aids the delivery of the extremities of the divided epicranial aponeurosis for accurate approximation (*Fig* 1064) Deep interrupted silk stitches are then passed through the scalp and tied—only tight enough to secure apposition (*Fig* 1065)

Wound of the Scalp with Loss of Substance.—Every effort should be made to reduce tension, the harbinger of scalp necrosis. By dissecting the scalp from the pericranium, the edges are more likely to be approximated easily Should there be a comparatively small deficiency of the scalp there is no better method than Cushing's Isle of Man incisions (*Fig* 1066). The limbs of the tripod must all curve in the same direction. The resulting flaps are mobilized from their attachment to the pericranium, after which each can be made to slide to the mid point of the defect, permitting suture without tension (*Fig* 1066 B). An alternative method to bring the edges together is shown in *Fig* 1067 while if the defect is long and narrow the reversed S extensions (*Fig* 1068) make apposition easy Fairly large defects (2 in. × 2 in.) usually can be closed by the sliding flap method (*Fig* 1069) A highly practical point to realize is that if bare bone is left at the bottom of the wound granulation will not occur until sequestration of the outer table exposes the diploë. This entails months of waiting On the other hand if at the time of the original operation a number of holes are drilled into the diploë of the bared bone, granulation will proceed apace allowing early skin-grafting to be undertaken (Porter and Shedden)

Avulsion of the Scalp (*Fig* 1070)—Owing to better protection of machinery compulsory wearing of caps by factory girls, and modern fashions in hairdressing avulsion of the scalp common enough in days gone by is now infrequent. In cases of extensive avulsion

Fig 1070.—Avulsion of the scalp with great loss of tissue requiring skin-grafting

of the scalp the patient may arrive exsanguinated. As soon as compatible blood has been obtained blood transfusion under pressure is given. While the second pint is being given by the ordinary gravity method the patient is taken to the operating theatre. If there is no loss of substance the edges of the scalp are trimmed and the scalp is sutured accurately into position. Thanks to the excellent blood-supply union often occurs, providing the avulsed area is attached by a reasonably broad base. With tissue loss, whenever defects remain after fashioning suitable flaps, Thiersch grafts are applied as an immediate dressing to all raw areas. In the event of damage to the periosteum which is unusual, the best course is to drill holes through the outer table of the skull leaving the wound open, and apply sterile petroleum-jelly packing skin-grafting can be performed when the cavity has become filled with granulations. In all cases systemic antibiotic therapy is given even so necrosis of the outer table of the skull is a possible complication.

Mrs. A W., aged 80 was brought to hospital with the entire scalp hanging over the nape of the neck. The pedicle which attached the scalp to the body was barely three inches wide. After trimming and cleansing the interior the parts were sutured into position. Healing occurred by first intention.

Electrical Burns of Scalp.—Experience with these injuries strongly supports Rowbotham's teaching that a wide and bold excision should be carried out immediately after shock has been treated. The defect is repaired by one of the plastic procedures described already

FISSURED FRACTURE

If a fissured fracture—a mere crack—is seen at the bottom of the wound, in most instances it can be disregarded. Many times I have been called to see a case where the house surgeon has found or thought that he has found, a fissured fracture. The picture of a fissured fracture of the outer table with extensive comminution of the inner is riveted in the mind of the student. In reality this phenomenon is of the greatest rarity in civil practice. *Should there be some hidden lesion, physical signs will indicate that the skull must be opened.* In the absence of these signs fissured fractures should be left alone.

Fig. 1071.—A good type of nibbling forceps.

It is quite another matter when hair or other foreign material can be seen driven into the fissure. In such cases adequate exposure is essential. Using a narrow gouge the outer table of the skull is trenched along the line of the fissure. In this way the foreign matter is removed with the bone. If it seems probable that foreign matter has been driven more deeply than the diploë, there should be no hesitation in making a trephine hole to one side of the fracture and removing with nibbling forceps (*Fig.* 1071) enough bone to ensure the desired end, viz. that not a particle of foreign matter remains.

COMPOUND DEPRESSED FRACTURES

Discard instruments used for excision of the soft parts. Employ a freshly sterilized set when operating upon the bone.

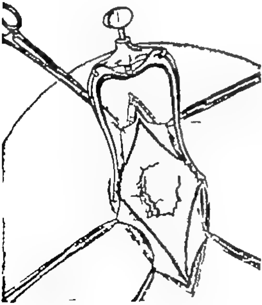

Fig. 1072.—By inserting a mechanical retractor the depths of the wound can be displayed adequately. In this case there is a depressed fracture.

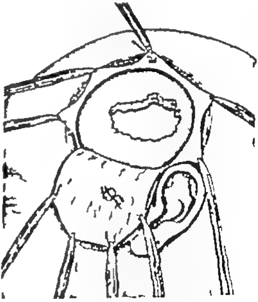

Fig. 1073.—The scalp wound has been excised and sutured, and the depressed fracture displayed by a horseshoe shaped incision.

If the scalp wound is a large one and displays the depressed area, a self retaining retractor will ensure a clear view of the deeper parts (*Fig* 1073) Usually such exposure is found to be inadequate in these circumstances there are two courses to pursue —

1 If the wound is comparatively small it is best to excise the edges, débride the interior suture the wound and then start the operation anew A horseshoe-shaped incision about the depression gives an unrivalled exposure (*Fig* 1078) It is made inch by inch blood being conserved by attending to hæmostasis of the scalp in the manner described already

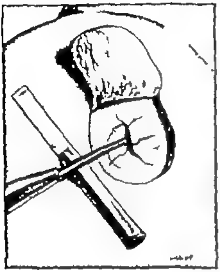

Fig 1074 —A method of elevating a depression applicable to some cases.

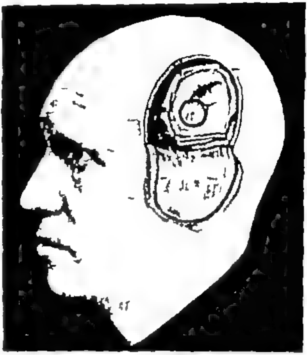

Fig 1075 —In depressed fracture always trephine sound bone

2. The scalp wound is enlarged by the tripod or sliding flap methods (pp 774 775).

Having excised and irrigated the wound with saline, and having obtained proper exposure of the depression, the periosteum is cleared from the bone and the area of the fracture examined closely It is usually necessary to trephine, the exception being when there is considerable comminution and pieces of loose bone can be removed (*Fig* 1074)

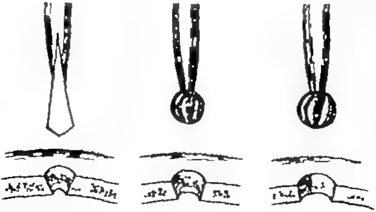

Fig 1076 —Doyen perforator and burrs. (*After Rowbotham and Hammersley*)

Always trephine sound bone (*Fig* 1073) is an axiom which will bear much repetition. The term trephine in this work does not imply that a trephine as such need be employed. If a trephine is the only instrument available a small one should be chosen. Doyen's burr (*Fig* 1076) is a safe instrument and if the choice exists it should be selected.

Via the trephine hole—a small hole is all that is necessary—the elevation of the depressed fragment is attempted (*Fig* 1077). If it comes up nicely into position, there is no need to do anything further Usually a considerable amount of the depressed fragment must be removed with nibbling forceps before the remainder can be elevated. Common sense must be used in deciding whether the damaged bone should be removed or left. *Fig* 1078, a diagram made at the time of the operation in the case of W P., may be helpful in emphasizing this point. In the presence of contamination it is better to remove too much bone than too little When a large loose piece of skull is removed it may come in useful for filling the cranial defect months later after the operation it can be boiled and stored in spirit.

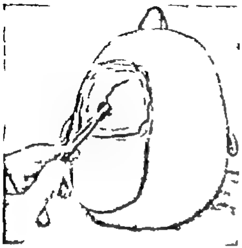

Fig 1077 —Elevating a depressed fracture.

Fig 1078.—Facsimile of the diagram which accompanied the case of W.P

When a limited area of bone is fragmented there is much to be said for making two, three or more trephine holes about the depression. The holes are connected with a Gigli's saw and the whole mosaic of damaged structure is removed, carrying with it the infected material.

THE CONTROL OF HÆMORRHAGE

Methods of dealing with hæmorrhage from the scalp have been dealt with already (p. 772) At this juncture it is necessary to consider measures for controlling bleeding from structures *deep* to the epicranial aponeurosis.

Bleeding from the Bone can be stopped by applying Horsley's wax, which is used sparingly In the absence of wax I have used BIPP[1] for the purpose and this has answered admirably It will however obscure subsequent radiographs, if such are necessary

Bleeding from a Branch of the Middle Meningeal Artery is seldom a matter for concern, for it is easily controlled by diathermy or if diathermy is not available, by under running the vessel with a fine curved needle charged with silk or cotton.

Bleeding from a Dural Venous Sinus is more perturbing and according to I Drewart such hæmorrhage is often uncontrollable. It is more probable that it is uncontrolled because the surgeon is unprepared for it, and unschooled in the special measures designed to staunch it.

Preparedness—First of all if the depression is near a dural venous sinus, the outer side of the thigh should be in a state of preparedness and accessibility Secondly when dealing with a depressed fracture in the neighbourhood of a venous sinus, nibbling with much discretion is the method least likely to damage this vulnerable structure.

Bleeding from a Sinus is Occurring—

1 It should be recalled that the venous pressure within the dural sinuses is low This is especially the case if the patient is not being stimulated with a general anæsthetic To tilt the table so that the head is raised and to administer oxygen helps to reduce intravenous pressure to a lower ebb.

2. To apply hæmostats to the wall of a bleeding intracranial venous sinus only results in widening the tear

3. Even torrential hæmorrhage from a venous sinus can be arrested by gentle digital pressure An excited surgeon unused to neurological technique may compress in such a

[1] BIPP—Bismuth, Iodoform, Paraffin, Paste

way that Pacchionian bodies, and possibly emissary veins in the neighbourhood may be injured, when even more severe hæmorrhage ensues.

4 The hæmorrhage having been controlled by digital pressure if ribbon gauze is packed between the dura and the skull on each side, the bleeding ceases and repair can be effected :—

a. If the tear is a comparatively small one, it should be covered with a postage stamp A flat piece of temporal muscle is cut away and beaten into a thin sheet (*Fig* 1070) A portion of this about the size of a postage stamp is pressed on the bleeding area with the finger for a full minute It adheres indeed, it can only be removed with a certain amount of difficulty

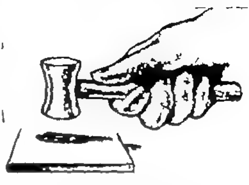

Fig 1070 —Making a postage stamp (*After Rowbotham and Hammersley*)

If temporal muscle is not available, through a 2 in. (5 cm.) incision in the outer side of the thigh we can immediately procure both fascia (*see below*) and muscle in unstinted quantities this is the ideal source of supply especially in emergency

b By suture while as a general rule the dura holds sutures well, that part of the dura forming the walls of the venous sinuses is reduced in thickness and, as a consequence, is much more difficult to suture. Eyeless needles carrying 000 catgut or silk are suitable for this very delicate work or failing this, the smallest spring-eye needle and very fine silk must be used. The suture line is reinforced by a postage stamp which in turn is covered with a suitable patch of fascia stitched to the dura. The packing is then removed

c. When the continuity of the sinus appears to be severed, each open end must be encircled with a needle carrying silk or cotton, and the ligatures tied. If available, large silver clips can also be employed for this purpose.

Bleeding from Cerebral Vessels.—Every size of bleeding cortical blood vessel, venous or arterial can be staunched effectively by diathermy (*Fig* 1080) if the luxury of silver

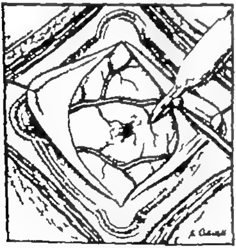

Fig 1080 —Diathermy of a small cerebral vessel.

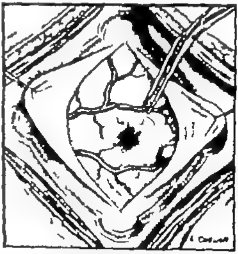

Fig. 1081 —Cushing's silver clips being applied to a bleeding cerebral vessel with Cairns angled forceps.

clips (*Fig* 1081) is not available In the absence of either bleeding from these thin-walled friable vessels is difficult to control by ordinary methods. Delicate underswing with fine cotton and tying with a half knot, seldom fails to make the operator master of the situation Persistent oozing from the brain surface can be staunched by the postage-stamp method

The Dura is Bulging and Plum Coloured.—The dura is opened by gentle linear stroking with the point of a large sharp cutting needle; as soon as the membrane is pierced the opening is enlarged with the finest of scissors. If the surgeon is provided with a mechanical sucker there is no better method than to employ it. When this extremely valuable apparatus

is not available a large well fitting syringe and a piece of rubber tubing can be made to serve the purpose. Suction through a small hole in the dura is the only method to be employed to remove blood which in this instance is nearly always fluid. The dura is then closed with interrupted sutures.

The Dura is Torn.—Theoretically the edges of the dura should be excised. Experience has shown that not only is this unnecessary but it is harmful (Sir Geoffrey Jefferson). Using suction, the underlying surface of the brain is cleansed of blood. Bleeding from the brain is usually venous and much of it ceases after warm applications. Wool rung out in hot saline is useful for this purpose. Alternatively the extremely good expedient of applying wool soaked in hydrogen peroxide is used by many neurosurgeons.

Should the Dura be closed? is a question that requires considerable surgical judgment —

1. If the wound is grossly contaminated and/or the patient has been operated upon only after some delay, the dura should be left open. The scalp is closed with drainage. In addition, a No. 2 rubber catheter is inserted into the depths of the wound for instillations of penicillin and streptomycin (purified for intracranial injection).

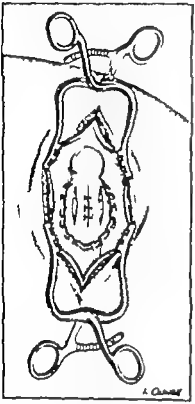

Fig. 1062.—When there is a slight loss of substance the dura can be closed by making lateral incisions to relieve tension.

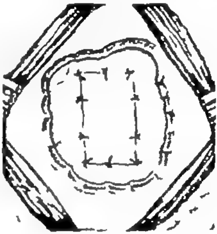

Fig. 1063.—Closure of the dura with a patch of fascia lata.

2. If the loss of dura is sufficient to require a fascial graft and the wound is apparently uncontaminated, but the patient's condition cannot be classified as excellent, the dura should be left unsutured and the scalp closed without drainage. In these circumstances additional expenditure of time required for patching the dura is unwarranted.

3. When the patient is in good condition, and the wound is but little contaminated, closure of the dura is advisable. It is usually impossible to bring the dura together if there has been even the slightest loss of substance. If by trial it can be shown that the edges of the dura can be nearly but not quite approximated, then the most traumatized area of the brain can be covered by the simple expedient shown in *Fig.* 1062.

4. In cases where the general condition of the patient is excellent, the wound uncontaminated, and the loss of dura considerable, the best *method is to patch the defect with fascia lata* (*Fig.* 1063).

The Underlying Brain is Pulped.—Clots and damaged brain must be removed. A suction apparatus is ideal for this purpose (*Fig.* 1064). Ordinary suction will not damage normal brain, but it will separate the non-viable from the viable. In the absence of a suction apparatus, a stream of saline solution and wiping gently with moist wool (gauze is too harsh) *will achieve the same end. Hemorrhage is controlled by* adopting the principles set out above. In cases where the dura has been opened by the surgeon it should be closed; in other circumstances the reader is referred to the section above *Should the Dura be closed?*

Compound Fracture of the Supraciliary Ridge.—This fracture frequently involves the frontal air sinus and even the ethmoid. If the posterior wall of the air sinus is intact there is no particular difficulty encountered. Often the posterior wall is fragmented and the dura torn In these circumstances C. C. Coleman advises removing all the broken bone and the mucous lining of the sinus. The dura must be closed, otherwise infection via the nasal passages will almost certainly lead to a fatal meningitis. Unlike other compound fractures of the skull, drainage of an area communicating with the nasal sinuses should always be provided.

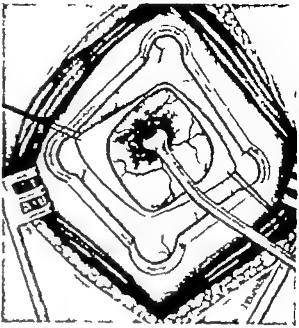

Fig 1084—Ordinary suction does not damage normal brain, but it will remove pulped tissue and blood-clot.

GUNSHOT WOUNDS OF THE HEAD

If a bullet or a piece of shrapnel is within the skull, a stereoscopic radiograph, or failing this a radiograph in two planes, is highly desirable. Under general anaesthesia, with supportive transfusions and antibiotic protection the wound margins are excised (*see Fig* 1062), and all contaminated tissue removed particular attention is directed to the excision

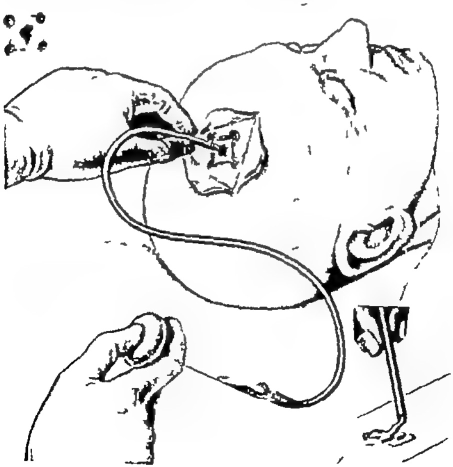

Fig 1083.—Method of dealing with a penetrating wound of the brain. (*After Harvey Cushing*)

of lacerated muscle. It was for this type of injury that Harvey Cushing evolved t
of Man incision (*see Fig* 1060). Four trephine holes are made so as to form a square
outskirts of the wound By means of a Gigli or de Vilbiss saw the quadrilateral p
bone with the penetrating wound in the centre is removed. Using a sucker the sup
clot and pulped brain are extracted If wound of the brain is superficial irrigatio
warm saline or hydrogen peroxide aided by the patient's coughing to cause extru
debris, combined with picking out bone fragments, is all that is necessary In th
of deeper wounds a rubber catheter is passed into the track of the missile The m
followed blood-clot in the interior and
cerebral tissue around the walls being with
by suction this is employed either t
a catheter attached to a suction appara
by the simple apparatus shown in *Fig*
Hæmorrhage from the white matter in the
is seldom profuse, and hæmostasis is
accomplished without difficulty by means o
cotton-wool packs soaked in hydrogen pe
If it is accessible, the missile of course sho
extracted indeed as long as it is govern
the utmost gentleness, every effort must be
to remove a foreign body for who can tell w
infected material has been driven in in f
it? On the other hand, bullets and pieces of shrapnel in themselves are sterile, a
is impossible to locate the bullet, we must comfort ourselves that many a patien
a bullet in his brain has remained symptom-free

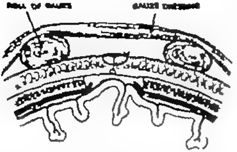

Fig 1066.—The principle of dressing the scalp when fungus cerebri is present or threatened. (*After G F Rowbotham.*)

If the foreign body together with the pulped cerebral tissue is removed, co
closure of the wound is followed by surprisingly good results. If it is impossible to r
the foreign body and/or a ventricle has been opened, the wound must be drained.

Fungus Cerebri is an unpleasant sequel of infected wounds of the brain. It is
the result of encephalitis. Usually about the tenth day or later the fungus com
to manifest itself through the unhealed scalp wound The excrescence should be pr
by a raised dressing (*Fig* 1066). Repeated lumbar puncture reduces the size of the
and the administration of antibiotics materially helps in controlling the encephaliti
old method of shaving off the fungus is never indicated. By conservative mean
fungi regress, granulations appear and the wound epithelializes.

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Surgeon Regional Neurosurgical Centre Walton Hospital Liverpool

CHAPTER LXIX

THE HEAD (*continued*)

No head injury is so slight that it should be neglected, nor so severe that life should be despaired of (Hippocrates.)

THE CARE OF THE UNCONSCIOUS PATIENT

ACCURATE observations, clearly recorded, are commenced at the time of the patient's arrival at the hospital. Of the many signs to be observed, none is more important than the degree of unconsciousness. Make painstaking inquiries from those who accompany the patient as to whether or not a lucid interval has occurred since the injury. Observe and make notes upon, the patient's response to verbal commands and to gentle or (if negative) to painful stimuli. These, together with a neurological examination and recording of the pulse-rate, the temperature, the rate of respiration, and the blood-pressure, form the basis upon which further observations are built. Improvement in the state of consciousness implies that the patient is recovering from the effects of the primary injury to the brain. Deepening of the state of unconsciousness gives warning of complications such as massive intracranial hæmorrhage or cerebral œdema.

Radiography.—Radiographs of the skull (and any other region, when indicated) should be taken with a portable apparatus as soon as the patient's condition justifies the procedure.

Posture.—Provided there are no other injuries preventing it being carried out, the patient is nursed on his side with one pillow, so that the head is horizontal with the body (*Fig.* 1087). In the lateral position the absence of a pillow results in undue stretching of

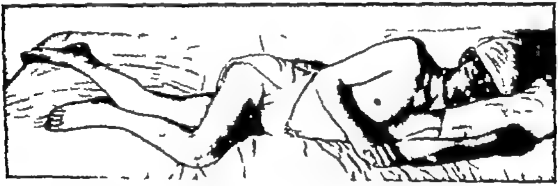

Fig. 1087.—The lateral position in which an unconscious patient should be nursed. (*Mr. C. B. Sedzimir.*)

the neck, which may impede venous return and embarrass respiration. As the unconscious patient is prone to many infections, especially of the lungs, a full course of penicillin is given. A special nurse is required.

Maintenance of a Clear Airway is of the utmost importance, and the primary duty of the surgeon and the nursing staff. Obstructed respiration and cyanosis cause increased cerebral congestion, increased cerebral anoxia, and increased intracranial pressure with aggravation of cerebral œdema. Pulmonary complications are also liable to develop. Partial obstruction, or even asphyxia can be due to such an easily remedied condition as the falling back of the tongue, which is liable to occur in a deeply unconscious patient not under constant observation, particularly one who has been permitted to lie on his back, and especially if the foot of the bed has been raised. Should the depths of unconsciousness be such that oral and bronchial secretions, or blood trickling from a fractured base or a facial injury, accumulate in the nasopharynx and trachea, an artificial airway (e.g., Hewitt's airway) and a suction apparatus are essential, and in many instances are sufficient to maintain

a clear airway Should these expedients prove to be inadequate some recommend the passage of an endotracheal tube. A very soft tube should be avoided as shown by D Blatchley and more recently by J W Dundee a soft tube is liable to become kinked, and thereby obstructed (*Fig* 1088) by flexion of the neck. An endotracheal tube smeared with glycerine to prevent encrustation, should not be left in situ for more than 24 hours. If a natural free airway is not established by that time without question tracheostomy must be performed.

Fig 1088.—A fault of the soft endotracheal tube The radiograph shows how it has kinked and respiration is obstructed (*Dr D Blatchley*)

In this work it is recommended that tracheostomy should be performed in cases of severe respiratory obstruction in the first instance In lesser degrees of obstruction an endotracheal tube is left in position for six hours, and if it is then judged that the patient is unlikely to recover consciousness for many hours, tracheostomy is performed. Early tracheostomy has saved the lives of many unconscious patients and has considerably reduced the total mortality of cases of head injury

Coleman s postural drainage (*Fig* 1089) for the unconscious should not be instituted in the early stages of treatment of an acute head injury It is sometimes of value in those patients who remain semi-conscious, or severely confused, for several days. This position should not be maintained for more than a few hours at a time.

Sir Robert Macintosh has drawn attention to the fact that war casualties repeatedly showed that injury reduces gastric motility and as a result the stomach will retain its contents for many hours afterwards. As R. Bryce-Smith observes, if the patient remains conscious this offers no danger to life In one whose reflexes are depressed as a result of either a head injury or a general anæsthetic, vomiting may lead to a fatal respiratory obstruction. Hence early gastric aspiration is a wise precaution, particularly if the unconscious patient has to be moved any distance

Fig 1089 —Coleman s postural drainage for the unconscious.

R. Bryce-Smith s Case —

A man aged 69 was admitted to hospital with a compound fracture of the frontal bones, the result of being knocked off his bicycle. In the casualty department he was deeply unconscious, but his general condition was satisfactory and his airway good. He was therefore sent direct to a ward. After he had been lifted into bed it was noticed that his respiration was stertorous. He was then slightly cyanosed and his pulse rapid and feeble. An anæsthetist was called but by this time respiration had stopped. A laryngoscopic examination revealed a considerable quantity of stomach contents in the pharynx and trachea. This was aspirated immediately and artificial respiration started, but the patient died within ten minutes. At necropsy the lungs were found to be full of vomitus.

Charts.—Accurate observations, clearly recorded should be the pride of those in attendance The first entry is that of the blood pressure The pulse-rate respirations,

and temperature are charted every half hour. A graphic recording of the size of the pupils also may prove to be of cardinal importance.

Taking the Temperature.—In intracranial injuries or lesions, it is unwise, and at times dangerous, to rely upon axillary readings of the temperature, because in cases of pyrexia of central nervous origin the mechanism of cutaneous vasodilatation is frequently upset or abolished. For this reason the internal temperature is often several degrees higher than that recorded on the skin. In cases of head injuries the only reliable method of taking the temperature is by placing the thermometer in the rectum.

The Significance of Pyrexia.—In primary injuries to the hypothalamic-thalamic complex, or to the mid-brain, a high temperature may be recorded shortly after the accident. Moderate degrees of pyrexia occur within a few hours as a result of traumatic subarachnoid hæmorrhage, and within two or three days from absorption from contusions and cerebral lacerations. At this later stage considerable elevation of temperature in the presence of a fracture involving the paranasal sinuses or the petrous portion of the temporal bone may be due to meningitis. It is, however, to a high temperature (101–106° F. (38.3°–41.1° C.)) present on admission, or developing within the first 48 hours after admission, that attention is directed particularly. Early hyperthermia bespeaks a primary injury to the thermo-regulating mechanism and usually other clinical signs of a mid-brain lesion are present (e.g. decerebrate rigidity). Very few patients with this type of injury survive, but during the last four years in the Liverpool Neurosurgical Unit 6 out of 10 such patients recovered following the use of induced hypothermia, tracheostomy and careful nursing. When a similar clinical picture develops after a few hours or two or three days have elapsed from the time of the injury, a massive intracranial hæmatoma (extradural, acute subdural, cerebral, or a combination of these) or massive cerebral œdema, is in progress. Shifts of brain and herniation into the incisura tentorii are thus produced, interfering with the circulation of midline structures. This results in deterioration of consciousness, dilatation of the pupil, hyperthermia, hyperpnœa, tachycardia, and, finally, in decerebrate rigidity.

Apart from the pathological manifestations of which hyperthermia is but an index, its continuation is, *per se*, injurious: metabolism is increased, and the oxygen requirements rise steeply, while the intracranial circulatory embarrassment prevents the increased oxygen demands being met. Consequently there results increasing anoxic damage to the neural structures damaged already by the injury. On the other hand, the reduction in metabolic rate and cerebral oxygen consumption that follows therapeutically induced hypothermia may allow survival and continued function of neural tissue in areas rendered anoxic or ischæmic by circulatory embarrassment. Just as hyperthermia is injurious, so is an extreme degree of hypothermia. It has been found that temperatures between 90° F. and 93° F. (34° C.–34.5° C.) are effective and safe. In the treatment of head injuries the temperature should never be allowed to drop below 90° F. (32.2° C.). The application of a hypothermic régime, the prevention of respiratory obstruction, and careful nursing is the sum total of the treatment that can be offered in primary injuries to the brain-stem.

When mid-brain disturbance is secondary to an intracranial expanding lesion, timely operative treatment is imperative, and the above measures become supplementary to it. An uncomplicated extradural hæmorrhage, if properly observed, should never be allowed to progress to the stage of secondary brain-stem compression with its poor prognosis.

A Hypothermic Régime.—

1. Hypothermic treatment is commenced when the rectal temperature reaches 100° F. (37.8° C.).

2. The pulse-rate, the respiratory rate and the *rectal* temperature are charted every half-hour.

3. Chlorpromazine 50–100 mg., with or without pethidine 25 mg., or levorphan, 2 mg., is injected intramuscularly.

4. After the injection of drugs the patient is left covered by a sheet only, and 30 minutes later tepid, followed by cold, followed by ice sponging is instituted, until the temperature falls to the required level (90–93° F.).

5. If the temperature does not fall to the desired level the injection of more drugs, and ice-bags applied over the heart and major vessels may be required.

6. The air passages must be kept free. Intubation or tracheostomy is carried out when necessary.

7. A fall of temperature below 90° F. (32° C.) or a rise above 100° F. (37.7° C.); irregularity or slowing or rising of the pulse-rate and/or of the respiratory rate; deterioration in the responsiveness, and any fits or paralysis, should be reported immediately to the surgeon for his assessment.

8. Hypothermia may be employed in secondary brain-stem damage only after appropriate surgical treatment has been performed.

CONCUSSION

Provided the surgeon has satisfied himself personally that the case is one of uncomplicated concussion, and he has inaugurated the system of supervision and nursing detailed in this chapter he is unlikely to be summoned until the patient has awakened. On awakening, the patient often complains of headache. He may be restless and photophobic, and his temperature will probably be moderately elevated. His pulse may be slow. This syndrome is sometimes called the stage of reaction. Headache may be the leading symptom; should it increase in severity one should suspect that the improvement in the state of consciousness is a lucid interval, and that it heralds the formation of a massive intracranial hæmatoma. Vigilance should be redoubled. As a rule the blood-pressure will be found to be raised. The now conscious patient is allowed to lie in bed in any position that he finds comfortable and if he so desires, he is propped up with two or three pillows.

An analgesic or a sedative is required, and depending upon the degree of restlessness and the severity of the headache, one of the following can be chosen:—

Pethidine, 50–100 mg. intramuscularly.
Chlorpromazine, 50–100 mg. intramuscularly.
Sodium luminal, gr. 3 intramuscularly.
Tab. codeine Co. 1–3 by mouth.
Morphine is contra-indicated (see below).

A mild purgative is also of value. To restrict the intake of fluids or to institute dehydration therapy (e.g., intravenous hypertonic solutions or magnesium sulphate per rectum) *is not justifiable in a conscious patient.*

FRACTURED BASE—CEREBROSPINAL FLUID LEAK

Fractures of the skull are unique amongst fractures, for the fracture is relatively unimportant. A radiograph displaying a fracture of the base of the skull is largely a matter of academic interest. In due course a film showing the fracture should be secured, largely as a protective measure for the surgeon in the event of litigation, but it is never justifiable to move an unconscious patient to the X-ray department for this purpose.

In the case of a fractured base of the skull, treatment is symptomatic and differs in no way from that of a severe concussion, except in the following particulars. If blood or cerebrospinal fluid is issuing from the ear, the discharge is mopped up at intervals with sterile gauze, but the external auditory meatus should not be plugged. Tamponade of the nares is also contra-indicated in the presence of cerebrospinal fluid rhinorrhœa. Under these circumstances (particularly with regard to the rhinorrhœa), it is obvious that the patient is in imminent danger of ascending meningitis. As a preventative measure full doses of penicillin and streptomycin are administered. *The patient must be warned not to blow his nose.* Wherever possible, all patients with cerebrospinal fluid rhinorrhœa should be transferred to a Neurosurgical Centre for further treatment.

SEVERE RESTLESSNESS AND DELIRIUM

Morphine is contra-indicated, for it tends to mask the all-important signs of intracranial space-occupying lesions. Loyal Davis says that when morphine has been given to a patient with a severe head injury, Cheyne-Stokes respirations—a herald of impending dissolution—sometimes disappear when the morphine has been stopped. These are convincing reasons why sedatives other than opiates should be prescribed. However, adequate sedation is necessary. A most valuable combination of drugs used at present is sodium luminal, up to 5 gr., with chlorpromazine 100 mg. by intramuscular injection. For quicker absorption these can be given with hyaluronidase. Intramuscular paraldehyde is sometimes useful in doses of 5–10 ml.

Retention of Urine.—Violent restlessness in an unconscious patient may be due to retention of urine and if that is the case it will cease when the bladder has been emptied. If small quantities of urine are passed at short intervals retention with overflow should be suspected on no account should increased frequency be allowed to persist without palpating and percussing the bladder The overfull bladder must be relieved by catheterization, with scrupulous attention to asepsis.

Neck Rigidity—Provided injury to the cervical spine has been excluded rigidity of the neck suggests either subarachnoid hæmorrhage or meningitis. Occasionally it may be due to tentorial herniation. In the presence of a known or suspected fracture involving the paranasal sinuses or the petrous bone the development of neck rigidity suggests the onset of meningitis. A lumbar puncture should be performed remembering that the presence of blood in the cerebrospinal fluid does not exclude coexisting infection, and that the fluid should be examined bacteriologically for organisms.

ACUTE CEREBRAL COMPRESSION

From the discussion on the clinical aspects of an expanding intracranial lesion (*vide* the section on the significance of pyrexia, p. 785), the concept of cerebral compression should now be clear Initially the expanding mass displaces the hemisphere medially Later the hippocampal gyrus of the temporal lobe herniates and becomes incarcerated in the incisura tentorii compressing the third cranial nerve displacing, rotating, and compressing the mid brain. The final stage is a hæmorrhage into the substance of the mid brain from the overstretched perforating vessels, and is the mechanism whereby death is produced. The cause of the compression may be extradural subdural or massive cerebral hæmorrhage or cerebral œdema around major contusions or lacerations.

Cerebral compression can, and must, be diagnosed on clinical grounds. If it is suspected, the only safe and permissible way of excluding or confirming the diagnosis is by exploratory burr holes. On no account should lumbar puncture be performed, for in these circumstances it is highly dangerous (promoting herniation into the incisura tentorii) and gives no information that cannot be deduced from clinical observation. For the patient whose condition is critical, the intravenous administration of

$$\left.\begin{array}{l}\text{15 per cent saline solution}\\ \text{50 per cent sucrose}\end{array}\right\}\text{aa 40 ml. (80 ml. total).}$$

is a valuable emergency measure for lowering intracranial tension sufficiently to tide him over while the operating theatre is being prepared.

All cases of suspected cerebral compression should have the scalp shaved. This may reveal a hidden hæmatoma and, if operation is decided upon, the scalp being already in a state of preparation, prevents delay

EXTRADURAL HÆMORRHAGE

A hæmatoma between the dura and the bones of the skull may originate from the middle meningeal vessels, dural sinuses, or diploic veins, the first being the *most common* source Wood-Jones showed that the grooves on the interior of the skull are made by the

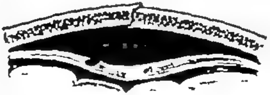

Fig 1000 —Extradural hæmatoma from a laceration of a vein which accompanies the middle meningeal artery (*After Wood-Jones*)

veins accompanying the middle meningeal artery and that *in many* cases of middle meningeal hæmorrhage it is the veins that are wounded (*Fig* 1000). As the hæmatoma forms, it strips the dura from the bone and many secondary bleeding points are added

The object of the operation is not only *to remove the clot* but also to arrest the hæmorrhage Although the main source of the bleeding may be from the anterior or posterior

branches, or from the main trunk of the middle meningeal vessels, the numerous small bleeding vessels make adequate exposure of the whole of the temporal area imperative. Small trephine openings over the anterior and posterior points of the middle meningeal vessels are entirely inadequate for more than simple inspection

SUBTEMPORAL CRANIECTOMY

Depending upon the state of consciousness and the patient's co-operation, either local or general anæsthesia can be employed. It is safer to give a light general anæsthetic than to have the patient struggling on the table. A vertical or a hockey-stick incision is marked midway between the external auditory meatus and the outer angle of the orbit, its lowest point being the upper border of the zygomatic arch (*Fig* 1091) To control bleeding while

Fig 1091 —The hockey-stick incision for exposure of the middle meningeal artery Exceptionally a second incision is required to expose bleeding posterior branch of the artery

the incision is being made, the scalp is compressed digitally (*Fig* 1092) The epicranial aponeurosis is picked up at short intervals with curved hæmostats, and everted over the subcutaneous tissue containing the blood vessels (see *Fig* 1063 *inset*). The temporal fascia, the temporal muscle, and the underlying periosteum are split vertically and on either side the periosteum is cleared from the underlying bone as far as possible. A self-retaining retractor (mastoid or thyroid type) is inserted, and all bleeding points in the muscle are diathermized. A burr-hole is made using a perforator and burr or if these are not available a trephine If using a trephine, remember to remove the pin as soon as a bite has been obtained. If an extradural hæmorrhage is present, blood and blood-clot will be apparent as soon as the opening in the skull has been made Enlarge the opening with nibbling forceps, mainly in a downward direction (*Fig* 1093) The lower border of the opening should extend as near as possible to the floor of the middle fossa (*Fig* 1094). When the opening is adequate commence removing the clots by suction. A large-sized blunt Volkmann's spoon or a small teaspoon, can be employed for this purpose. Warm saline solution run into the wound aids in the evacuation of clotted blood. Bleeding points are now dealt with Exceptionally the middle meningeal artery is torn at, or very close to, the foramen spinosum. In such an event the foramen is plugged with a small piece of sharpened, boiled wooden matchstick. If the vessels are torn in a bone groove or tunnel, or should hæmorrhage originate from the diploic veins, the application of Horsley's wax will stop the bleeding Bleeding from branches of the middle meningeal artery and other dural ooze will be arrested effectively with coagulation diathermy If diathermy is not available the middle meningeal vessels are under run with a fine round bodied, curved needle carrying a silk or cotton

ligature, care being taken not to damage intradural structures. There remain[s] of hæmostasis when the hæmorrhage originates from a major dural venou[s]

actual bleeding point will always be out of sight. Strips of temporal muscle are cut and prepared as shown in *Fig* 1079. The area from which the hæmorrhage comes is packed with these muscle-grafts, and the wound is filled with cotton-wool soaked in hydrogen peroxide. The latter is removed after a few minutes. Fibrin foam or gelatin sponge may be used in addition to the muscle graft. As a last resort the area is packed firmly but very gently with ribbon gauze which should be removed under vision in 48 hours by re-opening the incision. When hæmostasis is satisfactory the wound is re-washed with warm saline solution. The temporal muscle, the temporal fascia, the epicranial aponeurosis and the skin are closed in layers, using interrupted sutures of silk or cotton. A small corrugated rubber drain is inserted, which is removed after 24 hours. Very rarely, when thick clot extends towards the occiput

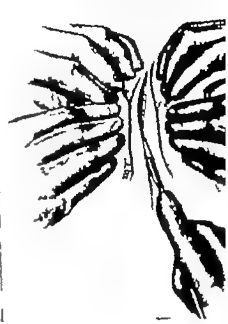

Fig 1092.—Control of hæmorrhage by
(*Rowbotham and Hammersl*

a second burr hole may be needed posterior to the ear (K. Mackenzie) (
Hæmorrhage from the Main Trunk.—This presents a more difficult pro

G. K., aged 23, at 6.30 p.m. fell from a motor lorry on to the pavement st
Admitted at 7.30 p.m., he was conscious. At 8.30 he vomited twice and it was
pupils were slightly irreg
was shaved and a hæmato
the right side of his temp

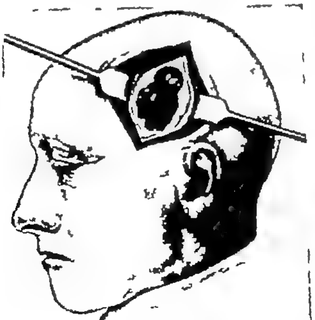

Fig 1093.—Extradural hæmorrhage. The burr hole has been enlarged with nibbling forceps.

Fig 1094.—The op
skull; it is a common
it too high and too far
Rowbotham and Hammer

9.0 he quite suddenly la
sciousness, and at 9.15,
unconscious and breath
The pupils were grossly un
large and fixed. There was bilateral rigidity of the limbs, which were so stiff th
described as imparting a sensation of rigor mortis. Without anæsthesia an incis

temporal bone was observed. On opening the skull much blood-clot was found and evacuated. Renewed hæmorrhage was serious and appeared to be coming from the under surface as opposed to the lateral aspect of the dura. With nibbling forceps the opening was enlarged right down to the level of the infra-temporal crest the dura was lifted up, and the blood poured out. I intended to plug the foramen spinosum with a match-stick, but it was at once apparent that this would be impossible, for the bleeding obscured the view Using strips of gauze, the area was packed for a moment, and after directing a light into the cavity a bleeding vessel was seen on the under surface of the dura. With a fine needle on a holder the middle meningeal artery was under run; as soon as the last was tied the bleeding ceased. The brain expanded well. The wound was closed in layers with drainage. Not until the fourth day did the the patient recover consciousness. When seen six months later he had recovered entirely

ACUTE SUBDURAL HÆMORRHAGE

Unfortunately cerebral laceration with subdural hæmorrhage is more frequent than the supremely remediable extradural hæmorrhage. Hogarth Pringle's 71 personal cases may be cited as a guide to the proportion which may be expected.

Intradural	38
Extradural	19
Both intradural and extradural	14

Diagnosis.—It is often very difficult to distinguish between extradural and intradural hæmorrhage Occasionally the lucid interval is absent in extradural hæmorrhage, while almost invariably it is absent in acute subdural bleeding Possibly there will be signs lateralizing the hæmatoma to the right or to the left hemisphere, but if the shift of midline structures is advanced, *false lateralizing signs* may be present. *Bilateral exploratory burr holes should always be made* do not leave this diagnostic necessity until the patient is moribund. If the hæmatoma is not evacuated, a fatal issue is inevitable If the operation is timely and the treatment of the state of unconsciousness is that described on p. 789, a few patients whose concomitant brain damage is not overwhelming, may survive.

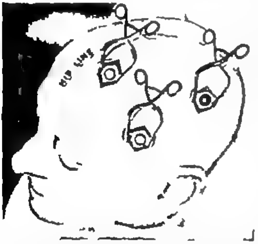

Fig 1005.—Exploration by burr holes (the *three on the left displayed*). *The anterior and* inferior burr holes display normal dura. The posterior show dura bulging and plum-coloured because of underlying hæmorrhage

Exploratory Burr holes are usually made under local anæsthesia, and four to six may be required. This also applies to an exploratory operation for chronic subdural hæmatoma, i.e that manifesting itself days, weeks, or years after an injury which is frequently trivial. The first burr-hole is made on the side of the larger pupil and is situated over the middle of the incision used for subtemporal craniectomy (*see Fig* 1001 The second burr hole is made in an identical position on the opposite side. In the event of these being unproductive third and fourth holes are placed 1½ in (3.8 cm) above and behind the *pinna Should these also yield* negative results, frontal burr holes are placed in the hair line about 1½ in from the middle line.

Normal dura is white blood beneath the dura is unmistakable (*Fig* 1005) The burr holes may be enlarged with nibbling forceps. The dura is opened in a cruciate manner using a No. 11 blade, with diathermy of resulting bleeding vessels. The clot can be fragmented and evacuated by using a No 8 rubber catheter through which warm saline solution is injected, and by the application of suction. When the clot has been removed and a cerebral laceration is visible it may be necessary to diathermize cortical vessels that are bleeding The dura is not closed and no drain is inserted. The epicranial aponeurosis and the skin are sutured. It is emphasized that although clot may be found on the side of the first burr hole at least one exploratory hole should be made on the contralateral side to exclude a bilateral lesion.

After the operation if not started already antibiotic therapy should be commenced as soon as possible.

UNCONSCIOUSNESS PERSISTS

One of several conditions is the cause of persistent unconsciousness with or without raised intracranial pressure and with or without the advent of new neurological signs.

1 Persistent cerebral œdema.

2. Ineffective absorption of cerebrospinal fluid due to traumatic subarachnoid hæmorrhage

3. Subdural hygroma

4 Thrombosis of dural sinuses and/or of cerebral veins.

5 Thrombosis of internal carotid artery

6. The condition known as post traumatic apoplexy

For the general surgeon who is unable to obtain expert neurosurgical advice the following management is suggested —

1 **Continued Deterioration with or without the Onset of New Signs.**—Exploratory burr holes, as described, should be performed. An unsuspected subdural hæmatoma may be revealed, or a subdural hygroma may be found and aspirated. If neither of these is present the condition of the brain should be noted. Does it bulge through the dura? If a brain cannula (*see Fig* 1104 p. 800) is available, tap the lateral ventricle and slowly release the cerebrospinal fluid, which may be under increased pressure. If one hemisphere appears to be more swollen, and signs of tentorial herniation are present, a subtemporal decompression may be performed on that side. In these circumstances a neurosurgeon may perform decompression by an extensive bone-flap and possibly attempt to disengage the herniation.

If the brain is swollen induced therapeutic hypothermia without dehydration has been practised with encouraging results in the Liverpool Neurosurgical Unit. The treatment in general use is that of dehydration therapy A word of caution is needed with reference to the latter Vigorous measures will result in general dehydration of the patient, which often proves disastrous. During the first 24 hours of unconsciousness 1 pint (568 ml.) of fluid, and during the second day 2 pints, are the barest minimum permissible This restricted fluid intake will leave the patient dehydrated by the third day At this time (i.e., during the third day) for trial purposes, 3 pints of fluid are given, and twice, at 6- to 12 hourly intervals, 50–100 ml. of 50 per cent sucrose are injected intravenously The patient must be examined carefully and assessed one and four hours after each injection Occasionally there is a dramatic improvement, but more usually the improvement is slight, or there is no change in the patient's condition. In any event there is no logical reason to persevere with further dehydration, and full fluid requirements should be given after the second dose of sucrose has been administered. It should be noted that the practice of instilling magnesium sulphate into the rectum for the purpose of dehydration is ineffective and should be discontinued.

Feeding by an intragastric tube will be required from the second, or at least the third day A mixture of milk eggs, and sugar should be given in divided doses every two hours, up to 2 pints daily Care must be taken that fluid does not regurgitate and find its way into the respiratory passages.

2. **Failure to Improve without Obvious Deterioration.**—This is a rather rare circumstance and the only instance in which a lumbar puncture is permissible

Measuring the Cerebrospinal Fluid Pressure—It is erroneous to suppose that the cerebrospinal fluid pressure can be estimated, even approximately by observing the rate at which fluid escapes through a lumbar puncture needle; a spinal manometer must be employed. Of several patterns, Guy's Hospital manometer (*Fig* 1096) will be found most satisfactory

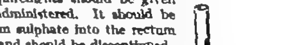

Fig 1096.—Guy Hospital spinal manometer

The special lumbar puncture needle (*Fig* 1090) is inserted, and the stylet is withdrawn until cerebrospinal fluid is seen welling up through the lateral opening The stylet is then reinserted to prevent the escape of fluid while the manometer tube is attached and held vertically As the stylet is withdrawn, fluid can be seen rising in the gauge.

Normal pressures vary between 100 and 150 mm. of cerebrospinal fluid when the patient is lying horizontally on his side Often the pressure rises above the normal at first but soon settles to a steady level which is marked by the slide attached to the tube. Pressures over 200 mm. indicate increased intracranial pressure.

If the cerebrospinal fluid is considerably blood-stained or xanthochromic remove enough fluid to halve the pressure reading If the pressure is raised this procedure can be repeated at 12-hourly intervals for 2–3 days, provided there is no subsequent deterioration. Fresh blood and its breakdown products cause much of the patient's restlessness, and often produce increased intracranial pressure through interference with free absorption of the cerebrospinal fluid. At the first suggestion of deterioration, exploratory burr holes should be performed.

DEPRESSED FRACTURES OF THE SKULL

Simple Depressed Fracture.—If the depression is in a relatively safe area, small and shallow and there are no focal signs, there is no indication for operative treatment. Large or deep depressions should be operated upon, but there is no immediate urgency When symptoms or signs *are* present, operation should be undertaken with the least possible delay

Fig 1097 —Depressed fracture of the frontal bone in olving the frontal air sinus with profuse rhinorrhœa. The opening in the dura has just been closed with the aid of a piece of fascia lata.

Operation for Depressed Fracture.—Make a wide semicircular incision about the depression right down to the bone but inch by inch. Methods of dealing with hæmorrhage from the scalp (i e., digital compression and forcipressure on the epicranial aponeurosis) have been described on p. 788. The principles involved in the elevation of a depressed fracture have been considered already (pp. 776 777). The only difference in this case is that the tendency will be to conserve major fragments of the skull.

Pneumatocele.—Pneumatocele is another danger of fracture of the frontal region involving the air sinuses occasionally it appears early but more often several weeks after the injury Sneezing followed by rhinorrhœa is almost pathognomonic of a pneumatocele Any fracture of the skull communicating with an accessory air sinus, particularly the frontal, should be watched most closely for the development of pneumocephalus. Patients with a fracture involving a sinus should be instructed not to blow their nose. Everything possible should be done to avoid sneezing and coughing Percussion gives a sonorous note. A radiograph clearly demonstrates the air within the skull If pneumocephalus is demonstrated early operation should be carried out, irrespective of the amount of air which is present Rhinorrhœa increases the urgency of the operation (*Fig* 1097).

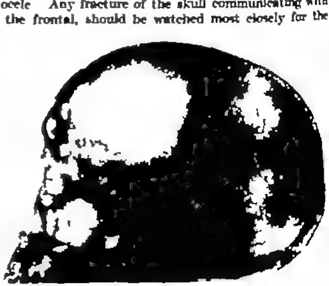

Fig 1098 —Pneumatocele. (*A Alcock British Journal of Surgery.*)

The operative measures which have proved most successful are evacuation of air and closure of the breach in the dura by suture or fascial graft (*see Fig* 1083). Usually as soon as the area is exposed, the air escapes, but in A. Alcock's case (*Fig* 1098) this could not be accomplished until a grooved director had been passed between the frontal lobe and the orbital plate Suture or

that a history of birth trauma is found only in about half the cases, gives the commonest clinical features as convulsions, persistent vomiting unexplained pyrexia, irritability and usually an enlarged head with a tense anterior fontanelle. The diagnosis depends on aspiration of a xanthochromic fluid tinged or even laden with blood from the subdural space the point of aspiration being usually near a lateral angle of the anterior fontanelle. Once the diagnosis has been made Guthkelch advises that the aspirations be continued daily for some ten days, during which time the child usually makes a remarkable improvement. Thereafter exploratory burr holes are made and if the characteristic membrane is found surrounding the hæmatoma, bone flaps are turned down and as much as possible of the membrane is dissected away.

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Revised by C. B SEDZIMIR, M.D F.R.C.S. (Edin.),
Surgeon Regional Neurosurgical Centre, Walton Hospital Liverpool.

CHAPTER LXX

INTRACRANIAL SUPPURATION

By FRANCIS BAUER, M.D (Prague), F.R.C.S (Edin.), D.L.O
Ear Nose and Throat Surgeon North Liverpool Group of Hospitals

and C. B SKUZINSKI, M.D F R C.S (Edin)
Neurosurgeon Regional Neurosurgical Centre Liverpool

THE incidence of intracranial suppuration has decreased since the introduction of antibiotics, and undoubtedly will diminish further when improved standards of education and hygiene induce patients with chronic infection of ears and sinuses to seek medical advice before intracranial spread of the infection has occurred. At present, however in geographical areas where chronic suppurative otitis media is common there is almost a seasonal incidence of cases of intracranial suppuration. As a rule a patient with this condition has neglected himself generally has decayed teeth, a foul discharge from one or both ears of many years duration, and severe deafness in the offending ear with cholesteatoma or aural granulations. His intelligence is often low

The type of intracranial suppuration present depends upon the speed with which the spread of infection has taken place. If, owing to virulence of the infection and low resistance of the patient, the process is rapid diffuse leptomeningitis results if it is slow the defences of the body are given opportunity to localize the infection and extradural abscess, a subdural empyema, cortical thrombophlebitis, thrombosis of the lateral sinus, or an abscess of the brain develop singly or in combination.

LEPTOMENINGITIS

Leptomeningitis due to *acute* otitis media does not require surgical measures, and should be treated by antibiotics alone. Leptomeningitis originating from a *chronic* middle-ear disease constitutes a surgical emergency because unless the source of infection is dealt with by early operation in addition to antibiotic treatment there is little hope of controlling the infection. In case of doubt as to whether the patient is suffering from an *acute* otitis media or an acute exacerbation of a *chronic* middle-ear disease radiographs of the mastoids should be taken. Good pneumatization is in favour of an acute infection sclerotic mastoid supports the diagnosis of a chronic middle-ear disease. Lumbar puncture is performed not only to confirm the clinical diagnosis, but mainly to identify bacteriologically the causative organism in direct smear and in culture, and to determine its sensitivity to antibiotics. It should be emphasized that the determination of sensitivity to antibiotics of organisms obtained directly from the cerebrospinal fluid is of far greater value than culture from an ear swab which usually contains a mixture of organisms, only some of which may have penetrated into the cerebrospinal fluid.

Antibiotic Therapy.—If the organisms prove to be sensitive to penicillin in addition to the usual parenteral injection, 20 000 units of a specially purified crystalline penicillin[1] solution is administered intrathecally once daily for several days. Before the injection of the penicillin solution a few ml of cerebrospinal fluid are withdrawn for a cell-count. With the subsiding meningitis the number of white blood-cells diminishes and polymorphonuclear leucocytes become replaced by lymphocytes. Professor L. P Garrod has emphasized the importance of correct combination of antibiotics in the treatment of meningitis. As explained on p. 112, if the organism is fully sensitive to a bactericidal antibiotic a combination of bactericidal and bacteriostatic antibiotics should be avoided.

[1] Ordinary penicillin contains phenol, which in no circumstances must be introduced into the subarachnoid space

Operative Treatment.—As soon as the patient has been saturated with the appropriate antibiotics, say within 24 hours, the source of infection (middle ear or frontal sinus) should be drained

If the source of the infection lies in the ear the operation should consist of post-auricular drainage of the mastoid antrum and middle ear uncovering the dura of the middle cranial fossa and of the lateral sinus, so as to release extradural pus under pressure (*see* p. 1060). The post auricular wound is packed *lightly* with ribbon gauze and left unsutured. If the general condition of the patient permits, and the surgeon is experienced in otological surgery a modified radical or radical mastoidectomy is performed, according to the operative findings, but the niceties of otological operations, namely adequate lowering of the facial ridge cutting of the meatal flap etc., are not emergency procedures and may be performed later

If the meningitis originates from a frontal sinusitis, the frontal sinus should be drained by an external approach (*see Fig* 1301 p 1071). The *floor* of the frontal sinus is exposed by a small incision in the inner third of the eyebrow the periosteum elevated and the frontal sinus opened by removal of a small area of bone with a gouge or a small trephine A drainage tube is introduced sutured to the skin, and retained for a few days. When the emergency has passed an external operation on the frontal sinus with drainage into the nose may be required The sphenoidal sinus should not be overlooked if the origin of meningitis is obscure Leptomeningitis may coexist with, or be due to, leakage from a brain abscess.

EXTRADURAL ABSCESS

Extradural Abscess of Otitic Origin manifests itself by pain in and above the affected ear in the homolateral temporal and parietal regions. This is due to retention of pus under pressure On post-auricular exposure of the mastoid antrum (*see* p. 1060) with each heart beat pus may be seen escaping under pressure through an erosion of the tegmen tympani or from the region of the lateral sinus (perisinus abscess). A specimen of the pus is taken for bacteriological examination and determination of sensitivity of the organisms present to antibiotics. Pulsatile expulsion of the pus, pathognomonic of extradural abscess, is due to pulsation transmitted from the dura mater which therefore lies exposed somewhere in the wall of the abscess, and must be displayed. The usually small opening in the bone through which pus escapes, is enlarged with a gouge, so as to assure adequate drainage and allow of inspection of the exposed dura The lateral sinus should also be exposed because extradural abscess is often associated with thrombophlebitis of the lateral sinus.

Extradural Frontal Abscess is suggested by excruciating frontal headaches in the course of frontal sinusitis. The abscess should be evacuated by entering the frontal sinus through its floor (*see* p. 1072) followed by removal of the posterior wall of the sinus. After evacuation of the pus the dura mater must be inspected carefully because a combination of an extradural abscess with a brain abscess in the frontal lobe is not uncommon. If a frontal *cerebral* abscess is suspected, do *not* open the dura and do *not* try to locate it by needling the brain. How to proceed under such circumstances is described on p. 790

SUBDURAL EMPYEMA
(syn Subdural Abscess)

A collection of pus in the subdural space occurs more frequently in acute infections of the frontal sinus than in the course of aural infection. It should be remembered that the subdural space is a potential space which is continuous around all the surfaces of the brain and of the spinal cord Usually there is a thin layer of purulent exudate which gravitates towards the most dependent parts of the subdural space Thus, with the patient recumbent the bulk of the abscess often lies in the occipital region, alongside the falx, even though the origin of the infection is in an empyema of the frontal sinus. It is important to remember this when planning operative treatment. It should also be pointed out that even in the dependent areas of the space pus rarely collects in an amount that endangers life by its space-occupying action. The greatest danger in this condition is produced by the infection resulting speedily in thrombophlebitis of the cortical cerebral veins with status epilepticus, paralysis, progressive toxaemia, and death. It is possible to argue that the subdural suppuration is secondary to thrombophlebitis, and that these two conditions are always present when a subdural abscess has formed.

When in the course of acute frontal sinusitis the temperature headache and toxaemia increase subdural empyema should be suspected. The patient becomes restless,

disorientated and may become very drowsy. Paresis of limbs and dysphasia[1] may or follow focal Jacksonian epileptic attacks. These become more frequent, and may generalized: status epilepticus is a lethal complication.

TREATMENT

1. Under local anæsthesia, the frontal sinus is drained as described on p. 1071

2. One, two, or more burr holes are made over the affected side of the skull, be in the frontal region just in the hair line and ¾ in. (18 mm.) from the midline. Th holes, which are made in the manner described on p. 777, are situated in a line to the sagittal sinus. Extreme care must be taken not to injure the cerebral vei the dura is opened. Usually only a very small amount of pus escapes under tens it may be possible to wash out a little more after insertion of a No. 3 catheter i subdural space. This must be done with care: do not inject more than 2–3 ml. o solution at a time, and if it cannot be recovered do not inject more. Catheters sh inserted to the most dependent accessible parts of the abscess along the medial of the hemisphere, forwards towards the frontal, and backwards towards the o poles, and also laterally over the convexity of the brain towards the base of th Purified penicillin alone, or with streptomycin 50–100 mg., is instilled through the ca Two ml. of thorotrast is also injected through the catheter leading towards the o pole. A few hours later radiographs are taken. If the thorotrast outlines a ca that region, as depicted in *Fig.* 1101, another burr hole should be made. This be situated above the angle made by the superior sagittal sinus and the lateral sin a *catheter introduced between the medial aspect of the occipital* lobe and the falx The performance of this burr hole is dangerous because of the vicinity of the mai sinuses, and should not be undertaken lightly by an operator unpractised in neuro technique. Daily instillation of antibiotics should be carried out for 5–7 days o if necessary. Massive doses systemically are, of course, also administered.

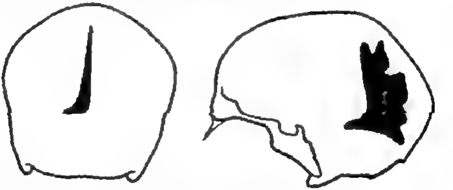

Fig. 1101.—Subdural abscess: to show appearances after injection of thorotrast.

3. Treatment of fits or of status epilepticus is of the utmost importance. Intram or even intravenous injections of sodium luminal up to 12 gr. (800 mg.) in divided do have to be given inside a few hours, and it may be necessary to resort to intraveno pentone, preferably administered by an anæsthetist, full anæsthetic precautions been taken.

4. Fluids should be administered by the intravenous route for 24–48 hours, or

BRAIN ABSCESS

At the outset of the era of powerful antibiotics it was hoped that together wit other lethal pyogenic conditions, brain abscess would cease to be a surgical eme Although, as a result of appropriate antibiotic treatment, the actual mortality and m from brain abscess decreased, it soon became apparent that this was due to a co surgical and antibacterial attack. As in other situations, when there is pus under antibiotics cannot reach the abscess cavity. Consequently, it must be acknowledg an emergency operation to release the pus is the all-important measure. Once the has been aspirated, antibiotic therapy can assist Nature in eradicating the infection

[1] Dysphasia = difficulty in speaking

is present to delay operation in favour of antibiotic treatment alone exposes the p to the fatal combined forces of infection and an expanding space-occupying intrac lesion The mechanism by which death is produced in the latter has been discussed on p. 787 It must however be emphasized that since many brain abscesses are si in the temporal lobe, tentorial herniation, with all its grave consequences, is apt to d more quickly than with a lesion situated in other areas of the brain Similarly att is drawn to the grave danger of impaction in the foramen magnum when the abs cerebellar

Aetiology—Almost invariably an otogenic brain abscess is situated in the te lobe or in the cerebellum adjacent to the petrous pyramid, because spread from the ear occurs either by continuity or by thrombophlebitis. The anatomical fact of spread anastomosis between the veins of the middle ear the venous sinuses, and and cerebral veins is well known. A brain abscess originating in the frontal air s situated in the frontal lobe. Jacksonian epileptic fits affecting the face and an limb and upper motor neurone type of paresis suggest a thrombophlebitic process. symptoms of thrombophlebitis of the cortical cerebral veins are rather dramatic, the time of their onset there may be no pus ready for evacuation (non-purulent en litis). Moreover with vigorous antibiotic treatment and surgical eradication of the of infection, the formation of a brain abscess may be prevented. These facts a *frequent difficulty of making a definite diagnosis of brain abscess by an inexpe* observer make needling of the brain through the infected area during mastoid op a dangerous and reprehensible procedure, because of the risk of introducing infection hitherto uninfected brain. Metastatic abscesses (from bronchiectasis, lung abscess, etc) the course of distribution of cerebral arteries, most commonly the middle cerebral They are often multiple. These and other more rare abscesses will not be discussed he

Diagnosis.—In addition to the signs and symptoms of infection, there will be due to a supratentorial or infratentorial space-occupying lesion Headaches, vo papilloedema, disorientation, restlessness, and drowsiness may all be present. In ac to these, the following signs localizing the infective process to some region of the must be sought.

Temporal Lobe.—Homonymous quadrantic hemianopic defect in the fields of is characteristic If the dominant hemisphere is affected, there will be, in addition degree of dysphasia.

Frontal Lobe.—There are no reliable localizing signs, but the disorientation and confusion may be gross.

Cerebellum—Headaches may be excruciating and giddiness marked. The p holds the head rigidly and tends to bend it forwards, resenting an attempt to m "almost as if they were trying to pull the cerebellar tonsils out of the foramen mag (J. Pennybacker) There will be nystagmus, becoming more marked as the time g and there may be dysarthria, ataxia, and dysdiadochokinesis with hypotonia of ipsi limbs. *The arm is usually more affected than the leg*

TREATMENT OF BRAIN ABSCESS

Both the brain abscess and the primary source of infection require urgent op treatment

1 *Timing*.—If the condition of the patient permits, namely when the signs impending foraminal impaction (see p. 785) are absent or minimal the induction of g anaesthesia is permissible and burr holes with aspiration of the abscess and mastoide are performed in this order at the same session. We strongly advocate this manag from personal experience

2. If the condition of the patient is more critical aspiration of the abscess sho performed first through burr holes made under local anaesthesia Mastoidectomy formed as soon as possible that is when the improvement in the patient's condition p the use of general anaesthesia usually in 24–72 hours. In exceptional circumstance the mastoidectomy can be performed under local anaesthesia (see p 1062).

3. In a frontal lobe abscess from an acute frontal sinusitis the abscess should be as through a burr hole and the frontal sinus drained at the same time (see p 1072). The tion on the frontal sinus should be of the simplest character at this stage a formal e operation on the sinus being postponed until the condition of the patient has imp

It must be stressed that a single aspiration of a brain abscess cures it only very rarely and the most conscientious observation of the patient, day and night, cannot be relaxed Sometimes even several aspirations are necessary and the state of emergency may not be over for several days. Finally if the abscess does not crenate and become cured by aspirations alone, it will have to be excised. This operation, however does not come within the scope of emergency surgery

What not to do We have already mentioned some important reasons why needling of the brain in search of an abscess should not be performed through the infected mastoid wound. Further since practically all the abscesses require more than one aspiration this should be undertaken through an uncontaminated area.

Needling through an infected wound may result in a localized or widespread encephalitis and suppuration, a tragic sequel of erroneous surgical management still perpetuated by employing outmoded methods. Of all the incorrect procedures the most pernicious is that which *Fig* 1102 illustrates.

In this patient an abscess was present but the operator did not find it. The operation on the mastoid was completed by a wide incision of the dura. The resulting fungus of the brain can be seen. Some days later the patient arrived moribund at the neurosurgical unit, and died soon afterwards.

Another patient with acute empyema of the frontal sinus underwent operation on the sinus. Brain abscess was suspected and the frontal lobe was explored through the posterior wall of the sinus. No abscess was found, but the ventricle was entered and a catheter was introduced through the needle track for drainage of the cerebrospinal fluid. Severe ventriculitis requiring prolonged treatment followed. This patient did not have an abscess!

Fig 1102.—Fungus of the brain in a case of a brain abscess following wide opening of the dura in the course of mastoidectomy without finding the abscess

We have seen cases in which, under the suspicion of brain abscess, the temporal lobe and the cerebellum were needled on the chance that it would be found in one of these situations. There was no attempt to arrive at a clinical diagnosis and localization on neurological grounds. Finally we have seen cases where temporal lobe abscess, although definitely diagnosed by clinical examination and present, was not found on repeated needling through the mastoidectomy wound.

Exploratory Burr-holes and Aspiration of the Abscess.—*A cerebral abscess should always be aspirated through a non-infected field.* If there is no abscess, infection is not introduced. Repeated aspiration can be performed easily without any delay if necessary with the patient in bed.

The position for burr holes in frontal, temporal and cerebellar abscesses are shown in *Fig.* 1103.

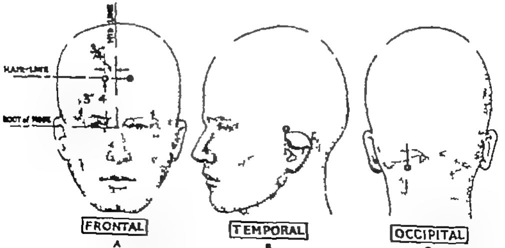

Fig 1103.—Sites of burr holes to be used i abscess of the brain.

Site of Burr holes.—

Frontal.—In the hair line 3–4 in. (7·5–10·0 cm.) above the root of the nose and ¾ in. (2 cm.) lateral to the middle line (*Fig.* 1103 A).

Temporal.—Directly above the external auditory meatus, as close to the junction of the scalp with the pinna as convenient (*Fig.* 1103 B).

Occipital (For cerebellar abscess).—At the mid-point between the external occipital protuberance and the tip of the mastoid (*Fig.* 1103 C).

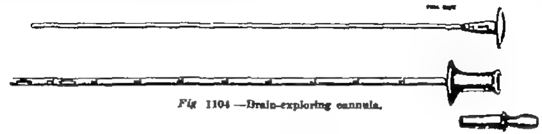

Fig. 1104.—Brain-exploring cannula.

The dura is opened in a cruciate manner with diathermy of bleeding vessels. The brain-exploring cannula (*Fig.* 1104) is inserted slowly. When the wall of an abscess is encountered, resistance may be felt.

In the temporal region the exploring cannula is directed downward and slightly medially, but if the abscess is not encountered, explorations backwards and forwards are carried out. The frontal lobe is explored downward and forward first, and then with a slight lateral, and if negative slight medial, deflection.

Exploration for Cerebellar Abscess.—A vertical incision 2 in. (5 cm.) long is made midway between the external occipital protuberance and the mastoid process. The nuchal aponeurosis and muscles are split down to the occipital bone. The occipital artery, which is rather tortuous, may be divided during this step in more than one place, but the bleeding can be controlled easily with diathermy. The burr hole is now made. The occipital bone presents itself in the depth of the wound at an awkward angle. The work will be facilitated if the neck is well flexed and if an extension piece is added to the Hudson's brace. The bone is rather thin, and great care must be taken during burring. The use of a trephine is contra-indicated. The dura, which is exposed a short distance below the lateral sinus, is incised and any bleeding point is coagulated with the diathermy needle. The exploratory cannula is introduced in an upward, inward, and lateral direction until the pus is found. This needling must be done with gentleness, always keeping in mind the position of the brain-stem. An injury to the latter may result in instantaneous death or grave disability.

Cerebellar exploration is difficult and dangerous, and we feel that its performance by anyone without considerable experience in neurosurgical technique is justifiable only in dire emergency.

Local treatment and Pyography.—After aspiration of the abscess purified penicillin 10,000–20,000 units, and streptomycin 30–100 mg., with 2 ml. of thorotrast are injected into the abscess cavity. The thorotrast becomes fixed in the walls of the abscess, and subsequent radiographs (lateral and antero-posterior views, *Fig.* 1105) at frequent intervals will give an indication whether the abscess becomes smaller and crenates, or enlarges and will necessitate further aspiration or excision. An indentation in the wall of an abscess may indicate an undrained loculus of pus. Unless an abscess collapses and becomes healed after two or three aspirations, the patient should be speedily referred to a neurosurgeon, whatever the situation of the lesion. A cerebellar abscess, especially, may enlarge very rapidly yet there may be little clinical change until fatal compression of vital centres is imminent. Consciousness may not be lost until a few minutes before cessation of respiration. Therefore if there is clinical deterioration, pyographs should be done urgently at any time of the day or night.

The results of treatment of a cerebellar abscess are not as satisfactory as those of a cerebral abscess in the previously mentioned situations. If there is difficulty with aspiration of a cerebellar abscess, major neurosurgical procedures such as suboccipital decompression or excision of the abscess may be required urgently, and such cases should be directed to a neurosurgical centre at the first opportunity. *References to any other method of diagnosis*

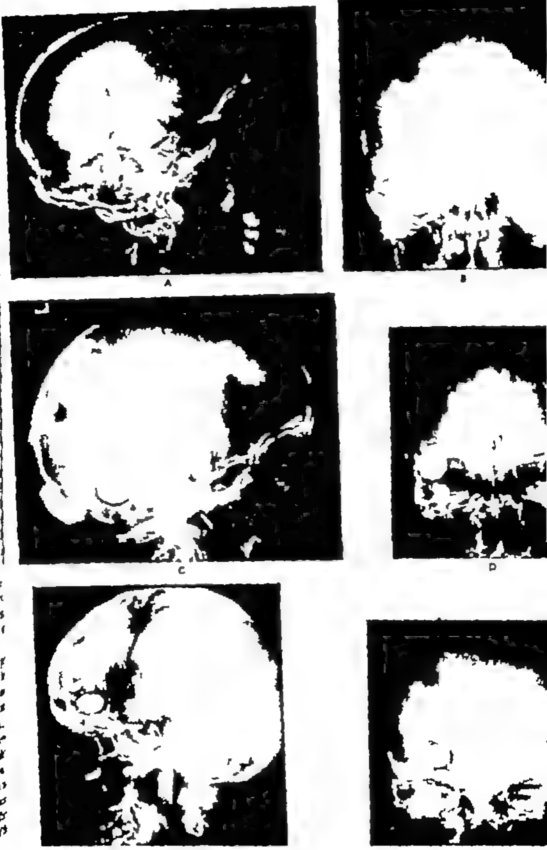

Fig. 1103.—Series of pyographs to show the outlining of intracranial abscesses after injectio[n] ... A, Shows a lateral view and B an anteroposterior view of abscess in *temporosphen*[oidal] ... C Shows lateral view and D an anteroposterior view of cerebellar abscess. E, Shows a la[teral view] and F an anteroposterior view of abscess in frontal lobe. (*R. H. Hannah's cases.*)

(ventriculograph, angiograph etc.) and to any other of the advocated methods of treatment are beyond the scope of this work.

Fits.—The same treatment as described in the paragraph on subdural empyema applies here

Cerebral Œdema.—In the presence of intracranial suppuration and thrombophlebitis, œdema of the brain may be a troublesome and dangerous complication. In an emergency while the preparations for burr hole and aspiration are being made and immediately after the aspiration in an unconscious and severely ill patient, intravenous hypertonic saline and sucrose mixture may have a beneficial effect For dosage and general views on this dehydration therapy see p. 98.

Antibiotics.—Local instillation into the abscess cavity at every aspiration has been described already Systemic antibiotics according to the sensitivity of the organisms must be administered in full doses. The remarks made on the subject in the paragraph on meningitis apply equally here.

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CHAPTER LXVI

THE FACE, THE JAWS, AND THE MOUTH

LACERATIONS AND KINDRED INJURIES OF THE SOFT PART OF THE FACE

The Time Factor.—Thanks to its abundant blood-supply the limit of 8 hours for primary closure that holds good for other parts of the body can, in the case of the face, be extended to 24 hours, provided the wound is clean-cut. When the tissues are contused and crushed, infection sets in early; consequently in such cases usually it is inadvisable to attempt primary closure after 8 hours, the guiding principle being whether or not œdema is present.

When the wound is œdematous the area should be washed with a weak detergent—always away from the wound—and the wound irrigated with normal saline solution. Moist dressings are then applied in such a way as to permit free drainage and the area is immobilized by a pressure dressing. The dressings are renewed at 48-hourly intervals.

Experience has shown that by these means and with the aid of systemic antibiotic therapy often a badly contused facial wound of more than 8 hours' duration can be rendered suitable for delayed closure in 48 hours, while an infected wound requires from 5 to 10 days before absence of œdema and the appearance of healthy pink granulation tissue proclaim that it is ready for operative repair. The instructions that follow apply particularly to primary closure, but in this instance they hold good for delayed primary closure.

Anæsthesia.—Except in children, local anæsthesia is preferable for the repair of most facial injuries. Local infiltration with 1 per cent procaine is often suitable, but nerve-block of the 2nd and 3rd division of the 5th cranial nerves, well described by J. B. Brown, is sometimes preferable to avoid distortion of the soft tissue. In this instance endotracheal general anæsthesia is not without serious objections. The unsterile apparatus passing to the nostril or the mouth is in the way; again, even if the endotracheal tube is left in until the patient appears to be almost round from the anæsthetic, blood in the pharynx, so frequently present in major facial injuries, is liable to be inhaled, especially if the patient lapses into unconsciousness after the tube has been removed.

Cleansing the Wound.—Local anæsthetic, if that be used, is injected after a preliminary washing. Facial preparation includes scrubbing with a mild detergent, the eyes being protected with pads of gauze during the procedure, which is always first carried out away from the wound or wounds. If the skin is grimed with dirt or grease, vigorous scrubbing with a brush is necessary. Loose hair and dirt must be sought and picked out. Cuts are commonly contaminated with tar or bitumen after road accidents. If allowed to heal without removing this foreign matter the resultant scars are pigmented. A correct initial toilet reduces the deformity and often the need for subsequent re-operation. Wounds impregnated with tar should first be washed with soap and water to remove the gross dirt and grit, then anæsthetized by rubbing in a topical application such as lignocaine, and cleaned with a tar solvent—oil of eucalyptus, turpentine, or petrol are the most effective, in that order. If no surface anæsthetic is to hand, a general anæsthetic must be given for this purpose.

A complication of facial injury by explosion of fireworks is that particles of gunpowder are peppered into the face; to a lesser extent particles of carbon and silicon in road dirt act in the same way. During the first 24 hours the points of entry are still open, and particles that remain after scrubbing should be picked out with a fine dental excavator; in so doing the use of a magnifying glass is of considerable assistance. General anæsthesia should be employed for this time-consuming procedure which, if neglected, results in gross disfigurement.

Débridement.—In contrast to excision of a wound elsewhere, débridement of a wound of the face is reduced to an absolute minimum. Referring to the skin of the face, R. H. Ivy wrote: "It is better to preserve skin that may die than to sacrifice any that may survive." Loose bone fragments should be retained if there is a hope that they might survive, and

if they are needed to support overlying tissue. Ragged skin edges are trimmed, tags of fat and muscle are snipped away while a piece of skin partially or even wholly detached should after removal of all its subcutaneous fat be replaced, sutured loosely into position, and protected by a firm dressing. When skin edges cannot be brought together without tension, under-cutting is required.

Suture.—After hæmostasis, which is often troublesome has been effected, according to its depth, the wound is sutured *in layers*. In the case of a deep wound stitches are passed through the thin muscular layer with its overlying fat in an inverted manner so that when each knot (*Fig* 1106) has been tied and its free ends cut, the knot will be buried. To secure a hair like scar accurate apposition of the base of the dermis must be obtained. This is achieved by inserting inverted intradermal sutures (*Fig* 1107) so that these knots are buried. For buried sutures some plastic surgeons prefer very fine silk others employ fine catgut. Lastly fine skin sutures are inserted, the cosmetic result being enhanced by employing skin sutures mounted on an eyeless needle. Skin sutures should be passed so that their points of entrance and exit are near the margins of the incision, but a broad bite of the subcutis is included (*Fig* 1108). In this way inversion of the skin edges is avoided.

Pressure Dressing.—Except in the case of a wound of the lip the nostril, or the eyelid, a pressure dressing should be applied. This prevents hæmatoma formation and œdema of the wound which delay healing. First a thin layer of gauze moistened with saline solution is placed over the area to absorb exudate. Over this is placed a layer of fine-mesh petroleum-jelly gauze. This in turn is covered by a large pad of cotton wool, mechanic's waste or a rubber sponge retained by an elastic bandage or flexible adhesive plaster

Skin stitches are removed on the fourth day

SOME DIFFICULTIES IN OBTAINING AN INCONSPICUOUS SCAR, AND METHODS OF OVERCOMING THEM

Puckering at the End of a Suture Line.—Frequently as a result of inequality in the lengths of the margins of the wound when the approximation of the skin is almost complete a pucker appears at the end of the suture line. The technique of remedying this awkward situation is shown in *Fig* 1109

Suture of Wound Edges of Unequal Thickness.—The dead space below the thinner flap can be obliterated partially by advancing fat from below the thicker flap (*Fig* 1110).

Closure of a Skin Triangle.—Necrosis of the apex of a skin triangle is almost bound to occur if approximation is effected by skin sutures only. The correct procedure is to bring the opposing surfaces of the *dermis* of the apex of the triangle into apposition by means of an intradermal suture passed as shown in *Fig* 1111. Skin sutures are then inserted and tied not tightly. Almost certainly this will ensure that the blood-supply of the triangle in question is not endangered

U-shaped Lacerations.—Among the most troublesome of all lacerations of the face are the so-called trap-door flaps caused by U-shaped lacerations. Even if sutured into position most carefully the flap becomes œdematous owing to interference with the lymphatic and venous flow. In anticipation of this happening some surgeons recommend primary small zig zag flaps similar to those described in the broken-line method of suturing the skin of the lip (*see Fig* 1112).

Loss of Tissue.—When a small or moderate amount of skin has been lost suturing can be undertaken after the skin has been undermined. When a skin defect is too great to be closed by direct approximation without tension a free full thickness skin-graft, taken from behind the pinna, often results in a satisfactory repair. In certain cases portions of tissue such as the tip of the nose are either hanging attached by a pedicle or are completely detached the severed portion should be washed in saline solution, the fat removed, and the detached portion sutured into position.

J N Roy's Case.—

A boy of 7 put his head through the head-lamp of a motor-car and in withdrawing it cut off the tip of his nose on the broken glass. The bleeding was controlled while the father was sent back to find the missing tip; this was washed in tepid saline and placed in saline at blood heat. Three hours after the accident the tip was sutured into place with silk, threaded on a conjunctival needle. A light dressing was placed in the nostrils and exteriorly and a metal splint was fitted over the tip. The nostril dressings were changed on the second day and thereafter daily; the external dressing was changed on the fifth day. A complete cure resulted.

EXPEDIENTS TO PREVENT AN UNSIGHTLY SCAR

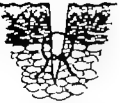


Fig 1106.—Deep
utures are passed in an
nverted manner so that
he knots are buried.
*After Kazanjian and
Converse*)

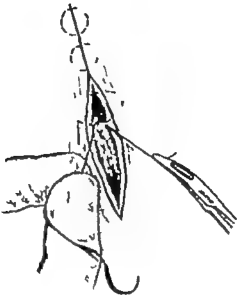


Fig 1107.—Method of inserting intradermal sutures. (*After Kazanjian and Converse*)

Fig 1108.—A method of inserting skin sutures
at oids inversion of the skin edges. (*After* T P
ber)

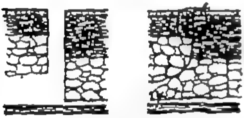


Fig 1110.—Advancing fat, in order to nullify excessive dead space beneath a flap thinner than its fellow (*After Kazanjian and Converse*)

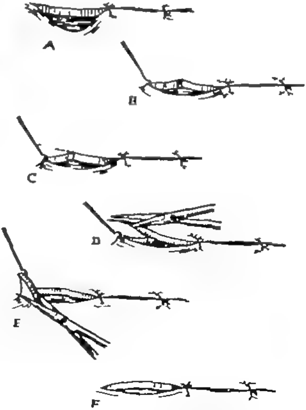


Fig 1109.—Method of overcoming puckering at the end of a line of suture (*After Kazanjian and Converse*)

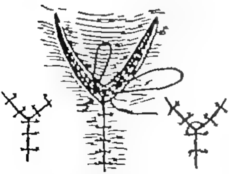


Fig 1111.—Method of closure of a skin triangle (*After Kazanjian and Converse*)

When a full thickness loss of the cheek is extensive and closure without distortion is impossible, the edges of the mucous membrane should be sutured to the skin edges. An impression of dental composition (stent) is made forthwith and placed in the area, thus preventing contraction of tissues until a reconstructive operation can be undertaken.

SPECIAL INJURIES OF SOFT PARTS

Laceration of the Lip.—To avoid disfiguring irregularity perfect apposition of the mucocutaneous border is fundamental. The next problem is, in full-thickness lacerations, to prevent deformity by the almost inevitable contraction of the scar which causes shortening of the lip notching of the lip margin, and eversion of the mucocutaneous border. These objectionable features can be circumvented in the following way: when the full thickness of the lip is involved, the first suture takes a firm bite through the mucocutaneous junction of the vermilion border. Traction on this suture causes other structures to fall into line. The continuity of the orbicularis oris must be restored; if this is omitted, there results a deforming depressed scar. Therefore sutures are placed from the buccal side, the mucous membrane and muscles being sutured with mattress stitches of fine silk through both layers. The vermilion border is then brought together with meticulous care. Attention is now directed to the skin. In order to avoid contraction of the scar the broken-line method can be employed with advantage. This small additional step is quite simple. It entails undercutting the skin and making two oblique incisions (X and Y) as shown in *Fig* 1112. The triangular flaps so formed are dovetailed. No dressing is required. The skin sutures are removed on the fourth day and the mucous membrane muscle sutures on the eighth day.

Fig 1112.—The broken-line method of suturing (*After Kazanjian and Converse*)

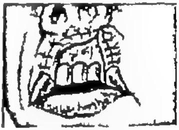


Fig 1113.—Suturing mucosa to skin as a temporary expedient after loss of a major portion of the lip

When a large portion of the full thickness of the lip has been avulsed, the interests of the patient are best served by stitching the mucosa to the skin (*Fig* 1113), and applying a petroleum jelly gauze pack, kept in place by adhesive plaster. Antibiotic therapy is given. The dressing is changed every 48 hours, and when oedema has abated a plastic operation is undertaken by an expert.

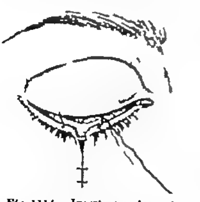


Fig 1114.—Inserting a stay suture the first step in suturing a clean-cut vertical wound of the eyelid.

Lacerations of the Eyelid.—While closure of a horizontal wound does not present any difficulty a vertical one—particularly if the full thickness of the lid is involved—requires especially careful technique which, however is within the competence of the general surgeon. When the wound edges are ragged, they should be trimmed as sparingly as possible. If, in a vertical wound, parts of the lid are damaged irreparably and must be excised, the defect should, if possible, be made triangularly with the base of the triangle at the lid margin. The wound edges are sutured in layers the first suture consists of silk mounted on an eyeless needle. It is passed through the margins of the lid so as to approximate them as accurately as possible (*Fig* 1114). This suture is not tied, but is used for traction and by its agency the corresponding structures will fall in line with each other. The conjunctiva and tarsus are approximated with buried sutures of 00000 chromic catgut in such a way that each stitch is passed through the tarsus only and tied upon it. This layer completed.

the orbicularis oculi muscle is approximated, and finally the skin is brought together with interrupted sutures of the finest silk. The stay suture is then removed

In wounds involving loss of tissue simple layer by layer approximation often results in notching of the lid margin. To avoid this unsightly complication the procedure known in carpentry as halving should be carried out. A small triangular piece of skin and the corresponding amount of the underlying orbicularis muscle is excised from one wound edge, the base of the triangle being at the edge of the wound. A similar shaped piece of conjunctiva and tarsus is excised from the opposite wound edge (*Fig* 1115 A) When the lesion is near the outer canthus the skin and orbicularis are removed from the medial edge of the wound The conjunctival tarsal layer is sutured in the manner described above then follows suture of the orbicularis muscle and finally commencing at the lid margin, sutures are placed as shown in *Fig* 1115 B.

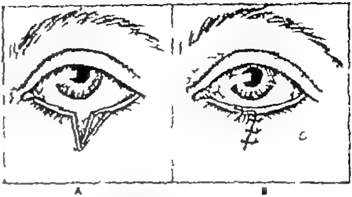


Fig 1115.—A. Repair of a vertical laceration of the eyelid with loss of substance by halving B The same completed. (*After Hans May*)

The operation having been completed, yellow oxide of mercury ointment is instilled into the conjunctival sac, the wound is dressed with dry gauze, and eye pads are applied to both eyes to reduce movements of the eyeballs. The skin sutures are removed on the fourth day but the marginal stitches (*see Fig* 1115 B) remain in place for 10 days.

When the defect consists of a large loss of skin of an eyelid, the defect should be closed immediately by a whole-thickness graft removed from the posterior surface of the pinna. A pressure dressing is applied by tying the lateral interrupted sutures (which have been left long) over it. In large full thickness defects of the eyelid a horizontal mattress suture should be passed through what remains of the lid and the lower third of the intact lid, and the suture tied over a piece of gauze to prevent cutting into the skin (*Fig* 1116). In this way the cornea and conjunctiva are protected until the services of a plastic surgeon are available.

Fig. 1116.—Temporary tarsorrhaphy

Laceration of the Nostril is particularly liable to give rise to notching if sutured in a straight forward manner The application of the halving and stepping technique (*Fig* 1117) is particularly valuable in avoiding this unsightly deformity

Laceration of the Auricle.—When there is loss of substance, so often does notching occur from contracture of scar tissue after simple suture that the technique of halving and stepping is recommended. A triangle of skin down to the cartilage is removed from the upper portion, and an exactly similar area of cartilage is removed from the lower portion, when suture by imbrication is carried out (*Fig* 1118). The viability of the cartilage of the auricle is low; many attempts have been made to suture an avulsed or an almost detached, portion of the auricle into position, but with no success unless the detached fragment is small and the replacement is undertaken very early This, and the fact that reconstruction of the auricle is one of the most difficult problems in plastic surgery should stimulate the emergency surgeon to bring together segments of auricle that retain a good blood-supply in the manner described

Hæmatoma auris.—Usually the result of injury (boxing) but sometimes occurring without a known cause this condition is due to accumulation of blood between the elastic cartilage of the auricle and its perichondrium and presents as a fluctuating swelling of typical appearance

(*Fig.* 1119). If left untreated the elastic cartilage, deprived of its nourishment, shrivels, and the unsightly "cauliflower ear" of boxers results. Infection of the hæmatoma may lead to perichondritis. In order to prevent both these possibilities blood and clots must be evacuated promptly and thoroughly by a small incision through the overlying skin and perichondrium. Pressure dressing is applied by padding the auricle behind as well as in front so as to bring the perichondrium, which has been elevated by the blood, back into apposition with cartilage. If blood or serum tends to

Fig. 1117.—Halving and stepping applied to a laceration of the nostril.

Fig. 1118.—Halving and stepping applied to a laceration of the auricle.

re-accumulate the incision may have to be re-opened with a sinus forceps. If, when first seen, the hæmatoma is infected already it should be incised and a small drainage tube inserted for 48 hours, and systemic penicillin administered.

Fig. 1119.—Hæmatoma of the pinna with perichondritis.

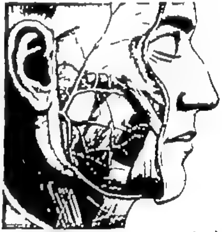


Fig. 1120.—The disposition of the facial nerve in relation to the face.

Injury to the Facial Nerve.—If partial or complete facial paralysis accompanies a wound of the face in the relevant area (*Fig.* 1120), while undertaking débridement of the wound a search should be made for the divided nerve so that it can be sutured. The search can be facilitated by using a sterile electrode to stimulate the distal end. Should facial palsy accompany a closed injury of the face it should be assumed that the paralysis is due to crushing of the nerve, pressure by a hæmatoma, or œdema, for in many cases facial muscular activity returns after a varying interval.

Injury to the Parotid Gland or Duct.—If the substance of the gland is involved in a wound, within a few hours there is likely to be a discharge of clear fluid. This continues for several days or a few weeks, and then ceases without incident. Therefore there should be no hesitation concerning suturing the skin over a wound of the parotid gland. On the other hand, if Stensen's duct is found to be severed at the time of débridement, a polythene tube of suitable size is inserted into the proximal end of the duct, and retained there by a catgut stitch. The mucous membrane of the cheek in front of the masseter is punctured with

fine scalpel, and the distal end of the tube is passed into the mouth The hole in the mucous membrane is closed about the tube with a stitch that transfixes the tube In this way probably a total persistent external salivary fistula will be avoided.

Injury to the Lacrimal Duct.—Occasionally the lacrimal duct is divided in association with a compound fracture of the frontal process of the maxilla and demands accurate repair as early as possible. Frequently the duct can be repaired over fine polythene tubing If the distal end cannot be found, a new canal will be formed if the tubing is brought through the nasal mucous membrane near the inferior turbinate bone

FRACTURE OF THE BONES OF THE FACE

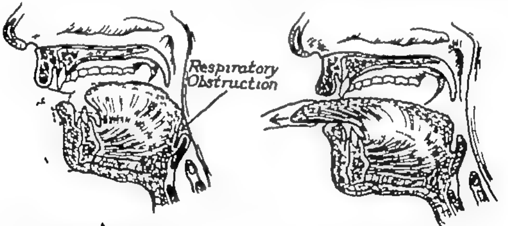
Fractures of the bones of the face, the mandible excepted, differ from most fractures because the displacement is produced by the trauma itself and not by the pull of attached muscles. On the other hand, fractures of the mandible are displaced by the very powerful muscles of mastication. Referring to the bones of the face as opposed to the mandible the weakest part of the complex is at the suture lines of the major bones as a consequence the fracture tends to follow stereotyped patterns (*Fig* 1121)

Fig 1121 —Common lines of fracture of bones of the face (*After Cannon and Murray*)

These fractures vary greatly in severity from a unilateral fracture of the nasal bones to compound smashed in face, an injury that is not infrequent. The victim is often the front-seat passenger of a motor-car who as a result of a collision, is thrown face forward against the wind screen or the dash-board.

Diagnosis.—When examination reveals a loss of normal occlusion fracture of one or other of the jaws is almost certain. An open bite usually signifies upward and backward displacement of the maxilla or fracture of the mandible in the region of the condyles. Flattening of the bridge of the nose often indicates a fracture of the nasal bones.

Severe bony injury of the face is frequently associated with a head injury Injury of the brain or fracture of the skull is possible by contre-coup for instance, a blow on the chin causing fracture of the mandible may produce a fracture of the base of the skull by



A B

Fig 1122.—A, Backward displacement of the tongue following bilateral fracture of the mandible causing respiratory obstruction. B Relief of the obstruction by pulling the tongue forward. (*After Kazanjian and Converse*)

transmission of force through the mandibular condyle Craniocerebral injury should be suspected in a patient who has been, or is, unconscious, and a thorough examination of the head and the central nervous system is called for

Transportation.—For transporting the conscious patient the upright position has proved best he is able to cough effectively and can rid the mouth of obstructing blood or secretion by leaning *forward*. The unconscious patient should be transported in the face-downward position.

In cases of bilateral fracture of the mandible for reasons that are apparent by reference to *Fig* 1122, or when the roof of the mouth (maxilla) is displaced downwards and backwards, the patient is often in imminent danger of asphyxia. Usually this can be averted by placing a stitch or a safety pin through the tongue, and keeping the tongue protracted. If this measure is not entirely satisfactory it is probable that clotted blood is obstructing the airway and tracheostomy should be performed forthwith

FRACTURE OF THE NASAL BONES

It is said that fracture of the nasal bones occurs more often than any other fracture except those of the wrist and the clavicle If a blow on the nose has been sustained, and the nose is bleeding fracture of the nasal bone should be presumed until the contrary is proved. Any blow upon the nose that causes intranasal bleeding signifies that a bone or cartilage has been broken and that the fracture has caused a breach of continuity of the mucous membrane thus the fracture is compound into the nose.

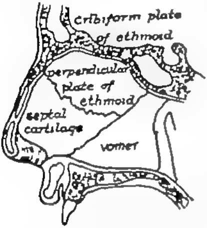


Fig 1123.—The component parts of the nasal septum, illustrating also that the cribiform plate of the ethmoid forms the roof of the nasal fossa.

The diagnosis is not always easy because swelling can obscure the deformity. A leakage of cerebrospinal fluid is suggestive of a fracture of the cribriform plate of the ethmoid (*Fig* 1123) When cerebrospinal fluid is admixed with blood, it is liable to escape detection. After the bleeding has been quelled by packing with adrenaline solution, any leakage of cerebrospinal fluid should become apparent. In all cases the nose should be inspected with a speculum. Deviation of the septum or a septal haematoma will be disclosed in this way but the possibility of pre-existing deviation of the septum must be taken into consideration As a haematoma often conceals a depression, if the patient has received a blow on the nose, and epistaxis has occurred an X ray examination should be carried out whenever possible Usually the radiograph will display a fractured nasal bone In addition it is valuable in confirming or eliminating a concomitant fracture of the maxilla or zygomatic arch There are two types of fracture of the nasal bones —

Fig 1124 —Depressed fracture of the nasal bones.

Fig 1125.—Fracture and lateral displacement of the nasomaxillary articulations and frontal processes of the maxillæ. The septal cartilage is dislocated from its groove in the vomer

1 *Depressed Fracture* due to a blow from in front causing one or more usually both nasal bones to be displaced inward and downward. Thus the bridge of the nose is driven in (*Fig* 1124)

2. *Lateral Fracture*.—One nasal bone is driven inward and the other outward the nasal septum being involved (*Fig* 1125)

Treatment.—If reduction of the fracture is undertaken early usually the displacement can be rectified with restoration of normal facial contour and re-establishment of a free airway

Anæsthesia.—General anæsthesia is best for children, but combined local and topical anæsthesia is perfectly satisfactory for adults. First, each nasal cavity is sprayed with cocaine 10 per cent and adrenaline 1–1 000 equal parts. Next the mucous membrane of each nasal cavity is anæsthetized by means of swab sticks saturated with the same solution three swab sticks are inserted through each nostril, one posteriorly one superiorly and one laterally (*Fig.* 1126) Finally the soft tissues over the nasal bones are infiltrated with 1 per cent procaine.

A long hæmostat is taken, and in the tip of its jaws is grasped a substantial wisp of cotton-wool which is so wound around the beak as to make a pad. The patient lies flat upon the operating table. The improvised elevator is introduced through the vestibule so that

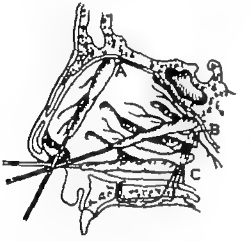


Fig 1126.—Topical anæsthesia of the nose with swab sticks saturated in cocaine-adrenaline solution. A anæsthetizes the anterior ethmoidal nerve; B anæsthetizes the sphenopalatine ganglion; C anæsthetizes the greater palatine nerv

Fig 1127.—Reduction of a fracture of the nasal bones using a padded long hæmostat fo levation and the thumb for moulding the nose into position.

it comes to lie beneath the fractured bones (*Fig* 1127) A depressed nasal bone is lifted upward and forward. With the free hand the nasal bones and the frontal process of the maxilla are moulded into position by pressure of the thumb of the free hand. If necessary the manipulation is repeated on the contralateral side.

In the same manner a laterally displaced nose can be lifted back into normal position. The septum is elevated and straightened, and returned to its groove in the vomer Do not be misled by trying to set in place a septum that was deviated before the recent trauma recent deviations are flexible.

When available the special forceps designed for reduction of nasal fractures should be employed instead of a padded hæmostat. Walsham s right and left nasal disimpaction forceps (*Fig.* 1128) are used with the larger blade covered with rubber tubing The smaller blade is passed up the nostril while the larger rests on the lateral aspect of the skin at the bridge of the nose In this way the bone is grasped and can be manipulated into correct position. If necessary Asch s septal forceps are then introduced on either side of the septum to re-aline the septal cartilage and replace the lower end in its groove in the vomer By means of these forceps the septum is grasped and slowly brought upward and forward to elevate the bridge of the nose

Wiring.—In badly comminuted fractures where there is a tendency for bones to fail to lock into position, with a resulting return of the depression, there should be no hesitation in employing a wire sling Two pieces of No. 24 stainless steel wire on a large curved cutting needle are passed, ½ in. (1 3 cm) below the other in the following manner the needle and it teel suture are inserted through the lateral fracture on the side of the nose, through

the cartilaginous septum, and thence through the lateral fracture on the opposite side. The two sutures thus placed are then passed through a flat lead plate placed on each side of the nose, and the wires are joined and tightened by twisting on themselves, thus forming a sling to hold the bones in position (*Fig.* 1129). The wires are retained for 10–14 days.

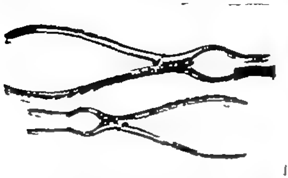


Fig. 1128.—Walsham's disimpaction forceps and Asch's septal forceps. (*Mr. J. Grant Bonnin.*)

Fig. 1129.—Fragments stabilized by two wires of soft stainless steel tied over lead plates. The soft tissues are protected by cotton-wool rolls. In this instance the wire has been passed as mattress suture. (*Rowe and Killey.*)

As a rule, after setting a fracture of the nose the nasal cavities are packed lightly with petroleum-jelly gauze for not more than 48 hours. Packing should never be employed if there is cerebrospinal rhinorrhoea. In all cases the after-treatment should include antibiotic therapy, which in cases of cerebrospinal rhinorrhoea is supplemented by sulphatriad by mouth, 1 g. 6-hourly for at least a week.

In many cases no external splint is required, although it is customary to place a piece of adhesive plaster over the bridge of the nose. After a lateral fracture has been replaced a light aluminium splint or, failing that, a splint of dental composition kneaded into the correct position, is advisable. Such splints are kept in place with adhesive plaster.

DEPRESSED FRACTURE OF THE ZYGOMATIC ARCH OF THE MALAR BONE

Because of its prominence, the malar bone is in a vulnerable position. The bone is strong, and consequently it is seldom fractured except by a penetrating wound. Inward displacement of the bone at its suture lines with shattering of the related thin wall of the antrum is, however, relatively common.

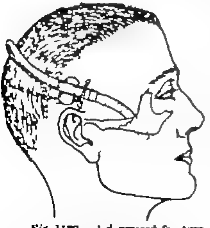


Fig. 1130.—A depressed fracture of the malar bone being elevated through a temporal incision. A Hegar dilator is being employed, with a roller bandage acting as a fulcrum. (*After Sir Harold Gillies et al.*)

Almost always there is unilateral epistaxis from tearing of the mucous membrane of the antrum consequent upon breaking of its outer wall. As a rule a black eye is present, together with conjunctival ecchymosis. Mastication is limited because of pain. Typically there is a flattening of the contour of the cheek in its upper part, which a few hours after the accident tends to become masked by overlying bruising and oedema. Even so, irregularity of the orbital margin at the malar suture line will be palpable, and there may be anaesthesia of the upper lip (infra-orbital nerve involvement).

When the roof of the antrum is fractured, sinking of the floor of the orbit may cause diplopia. Opacity of the antrum on the affected side, due to the blood contained therein, is apparent on transillumination and in the radiographs.

When the zygomatic arch is depressed inward, forward movement of the coronoid process is impeded, thus reducing the normal mandibular excursion.

Treatment.—As soon as possible the malar bone should be elevated. A curved incision is made $1\frac{1}{2}$ in. (3·8 cm.) long over the temporal muscle and well within the hair line. The

edges are retracted and a small incision is made in the temporal fascia. A long thin elevator (a narrow Hegar's dilator a screwdriver a periosteal elevator) is passed downwards on the surface of the temporal muscle until it lies deep to the displaced bone A roller bandage is used as a fulcrum under this lever and the malar bone is disimpacted and elevated (*Fig* 1130) The instrument should be passed beneath all parts of the depressed bone from the zygomatic arch to the orbital margin The fingers of the left hand palpate the arch and the inferior orbital margin while these manœuvres are in progress in order to determine the amount of elevation necessary Usually the reduced fragments lock themselves in place Reposition of the membranous bones of the antral wall is likely to occur if the major bone is replaced

This method has been employed in Böhler's clinic Vienna for 40 years and 100 per cent satisfactory results have been obtained Neither wire extension for maintenance of the position nor sutures to close the wound have been employed in this clinic and no case of infection has occurred (R H Schoenbauer).

Should the malar bone become redisplaced when the lever is removed, the best course is to enter the maxillary antrum by the Caldwell-Luc approach (*see* p. 1074) through an incision in the mucous membrane of the gingival sulcus. Loose fragments of bone are removed the depressed fracture can be raised upward and outward from within the antrum with the little finger and the inferior orbital margin reconstituted. The antrum is packed with petroleum-jelly gauze and the free end of the gauze is brought out of the incision which is left unsutured. The pack is removed in five days (Nesbitt and Leeds)

SMASHED-IN FACE

In severe cases of smashed in face, the patient is admitted with the features distorted and covered with dried, and fresh blood and dirt. Usually in addition to severe laceration of soft tissues compound fractures of the maxilla nasal bones, and possibly the mandible, are present as well Not infrequently there is mechanical obstruction to respiration through the nose and blood is coughed up from the pharynx at frequent intervals.

A major difficulty in dealing with the emergency situation is one of anesthesia. If intratracheal anesthesia is impossible, the first step is to perform tracheostomy (*see* p 880) under local analgesia, to be followed by a general anesthetic through the tracheostomy tube Once the patient is satisfactorily and safely anesthetized the wound can be excised and compound fractures attended to in accordance with accepted principles under antibiotic protection.

FRACTURE OF THE MAXILLA

Transverse fractures of the maxilla are the most serious, and usually the most difficult, fractures of the face to treat. Two types are encountered —

Upper transverse fracture of the maxilla crosses the bridge of the nose involving the nasal bones, the frontal processes of the maxillæ and, usually the lacrimal bones and ethmoids.

Lower transverse fracture traverses the facial bones at the level of the maxillary antrum (*see Fig* 1131), separating the alveolar process from its superstructure

In both these types of fracture the most significant deformity is elongation of the face Especially with the lower fracture there is mal-occlusion of the teeth, due to downward and often backward displacement of the inferior fragment carrying the teeth. Occasionally the lower fragment is drawn backward so that the airway is partially obstructed Epistaxis is usual.

Treatment.—After manual reduction one method of fixation is by a plaster head-cap incorporating a strong wire projecting downward from the forehead. Dental upper and lower cap splints are made the upper having a straight bar attached in the midline and projecting out of the mouth. After cementing the capped splints to the jaws, the displacement is reduced and the projecting bar is connected to the forehead wire by a rod and universal joints, thus maintaining the fracture in a correct anatomical position. This method requires the services of a dental expert with full dental laboratory facilities.

Internal Wiring.—For the average surgeon without the facilities and special skill of those comprising a facio-maxillary unit internal wiring is the only practical expedient and if carried out according to the instructions of W M Adams it gives most satisfactory results. A large cutting needle is threaded with a long piece of (preferably soft) stainless steel wire that will fit its eye or a sharp aneurysm needle can be employed. The needle is passed

from just above the zygomatic arch deep to the arch, and is made to emerge in the buccal sulcus adjacent to the second molar tooth. This end of the wire is drawn out of the mouth, and the needle is disengaged. The needle is threaded on to the other end of the wire and is passed similarly, although this time *superficial* to the zygomatic arch; it is made to emerge a little anterior to the first portion of the wire. The needle is disengaged. A tiny incision is made to connect the two skin punctures transmitting the wire. Grasping each free end of the wire in a hæmostat, the wire is moved to and fro with a gentle sawing movement that will cut through the soft tissues, and the loop of the wire comes to rest on the bony zygomatic arch. The procedure is repeated on the opposite side.

The fractured bone is elevated to its normal position. The wires are then attached to one or more teeth. Should the patient be edentulous the wires can be attached to the denture provided it is intact; otherwise dental wax (stent) is moulded around the alveolar margins and over the hard palate, and the wires are drawn across the middle line, twisted together, and after cutting off excess, the ends are embedded in the wax.

Alternatively, when the orbital margins are indubitably intact, a preferable method is to make a small incision over the infra-orbital ridge on either side. While protecting the eyeball with a spatula, a hole sufficient to accommodate No. 28 stainless steel wire is bored through the infra-orbital ridge. The wire is threaded through the hole, looped over the ridge, and both ends are passed together so that they emerge in the upper sulcus above the first molar tooth (Fig. 1131). It is surprising how readily the wires can be directed to the desired point. The remainder of the operation does not differ from that described above. In these ways the loose lower fragment is kept hoisted to its superstructure. At the end of a week, should the radiograph suggest that it is necessary, the wires are tightened.

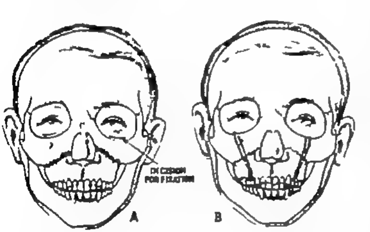


Fig. 1131.—A, Transverse fracture of the maxillæ. B, Maxillæ elevated and maintained in correct position by wires extending from each infra-orbital ridge to the upper molar teeth. (*After H. M. Adams.*)

The sling remains in place 4 or 5 weeks, during which time frequent mouth washes are given. Antibiotic therapy is continued as long as is thought necessary. When the time comes for the wires to be removed, to obviate transmission of infection, they should always be removed via the mouth.

Vertical Fracture of the Palate with Separation.—The diagnosis is obvious, because there is a visible split that can be likened to a cleft palate, with a wide gap between the central incisors, if they are present. First-aid treatment consists in fixing strong elastic bands to the teeth on opposite sides of the upper jaw; this expedient often succeeds in reducing the displacement. Should this fail, a cap splint should be fitted to the upper teeth on each side. These splints are both connected by a bar so constructed that it can be shortened by a screw attachment.

If the patient is edentulous two wires must be passed from one side to the other at the level of the superior borders of the alveolus, just below the hard palate. The ends of the wire are brought through and tightened over a felt pad placed on the anterior part of the alveolus of each side.

An Alveolar Fracture frequently is associated with displacement of the teeth it carries. The displacement is reduced by manipulation and fixation secured by a cap splint.

FRACTURE OF THE MANDIBLE

The usual sites of fracture are shown in *Fig.* 1132. The immediate treatment is to apply a "barrel" bandage and administer penicillin systemically. As soon as convenient a more efficient and permanent form of splint must be constructed.

Interdental Wiring.—When the patient has sufficient teeth intermaxillary wiring is eminently satisfactory This method has many advantages over the dental cap splint, not the least being that it is unnecessary to take impressions and make casts of the teeth. It should be noted that loose broken or carious teeth in the line of the fracture should be extracted.

Treatment by Interdental Wiring —Procure some copper wire gauge 22, or if this is unobtainable stainless steel or silver wire of the same size may be used. Copper wire has

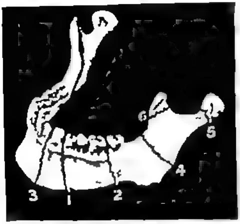


Fig 1132.—Usual sites for fracture of the lower jaw in order of frequency 1 The most common 6 The rarest

Fig 1133.—Wire pin for interdental wiring

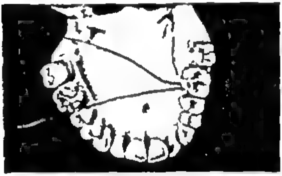


Fig 1134 —Threading the wire pin between two teeth.

certain advantages, and if it can be obtained, so much the better Some stainless steel or silver wire, gauge 24 is also necessary Taking the thicker wire make four wire pins, each 4 in (10 cm.) long of the shape shown in *Fig* 1133 The free ends of these pins are pointed by cutting the wire obliquely Have these four pins and the finer wire sterilized with the instruments.

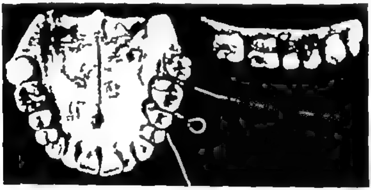


Fig. 1135.—Bringing back the ends of the pin between the adjacent teeth The inset shows the wiring of one of the fixed points completed.

A general anæsthetic is usually advisable but is not always essential. *If a general anæsthetic is to be employed, be certain that the stomach is quite empty* The danger of post-operative vomiting when the mouth cannot at once be opened will be obvious to all

The principle involved is to wire the lower jaw to the upper on either side of the fracture This entails having four fixed points, two on the upper jaw and two on the lower Each of these fixed points is constructed in the following manner One wire pin is threaded through the space between two teeth, in the manner shown in *Fig* 1134 so that the eyelet is on the labial side The free ends of the pin are brought back through the interdental spaces immediately in front of and behind the original penetration. The

wire is twisted until it grips the teeth firmly Excess of wire is cut off, and the twisted knot is pressed and rapped until it lies flat (*Fig* 1135). The first fixed point is made behind the fracture the second in front of the fracture the third and the fourth, which are in the upper jaw are made to lie as nearly as possible opposite the first and the second. The time has now come to bolt the lower to the upper jaw A double strand of the finer wire is passed through the opposing loops and gradually tightened (*Fig* 1136). Before the final tightening the fracture is manipulated into the best possible position, and is held by the assistant until the tightening is completed. The twisted ends are pressed down so as not to impinge upon the buccal mucous membrane.

After-treatment —Contrary to what might be thought, the patient almost at once learns to take a liquid diet either through a straw or directly from a cup The liquid diet can be varied and should contain some fruit juices and soups as well as milk preparations and vitamins it should provide 3000 calories a day With such a diet the patient will thrive After each feed an antiseptic mouth wash must be used, and twice a day a powerful spray is applied to the teeth. If the fracture involves little or no loss of bone substance the wires can be removed in six weeks. A longer period may be necessary and this in part will be determined by the radiograph. An anæsthetic is not necessary for the removal of the wires. The wire does not loosen or destroy sound teeth.

Fig. 1136 —The wiring complete

Fracture of the Mandibular Condyle occurs on one or both sides, usually from a blow on the chin. In adults with sufficient sound teeth, this type of fracture can be treated by interdental wiring In children or in the edentulous or nearly edentulous adult T R Broadbent has found that nasomandibular wiring is a safe and effective method of treatment

Preferably under local anæsthesia, and with the use of a No 16 spinal needle a No. 22 stainless steel wire is passed circumferentially around the mandible in the middle line in the following manner the lower lip is everted and the needle is passed close to the bone until its point emerges in front of the tip of the chin The wire is passed down the needle and the needle is removed The mouth is opened, the tongue is elevated and, keeping as close to the bone as possible the needle is passed, strictly in the middle line, from the floor of the mouth until its point emerges beneath the chin. An incision is made through the skin connecting the point of emergence of the wire with the point of emergence of the needle The wire protruding from the wound is then passed through the needle from its point to beyond it hub in the floor of the mouth, and the needle is removed. A single skin stitch closes the wound below the mandible The wire has now been placed around the lower jaw

The upper lip is everted and a transverse incision is made in the buccolabial sulcus. The soft tissue over the nasal spine is elevated and the spine is exposed. The extreme base of the nasal spine (which is well developed even in children) is perforated with a bone drill. The mandibular wire is passed through this hole and the incision in the mucous membrane is closed with two or three 000 catgut sutures.

The ends of the wire are twisted to bring the mandible into occlusion with the following preliminaries. Before the wire is tightened dentures are replaced—if the patient wears them, and if they are not broken but for the edentulous patient with no dentures the splint alone serves well. On the other hand if the patient has upper but no lower teeth a lower temporary denture is of advantage in obtaining correct alinement of the fracture During the period of fixation the upper gum occasionally need protection by a small felt pledget usually this is unnecessary if the posterior loop of mandibular wire is brought anterior to the teeth by passing it between the lower incisors at gum level. The ends of the wire are twisted tightly to bring the mandible into occlusion The wire is further tightened as necessary and immobilization is maintained for four to five weeks. At the end of this time the wire is removed by severing it at gum level beneath the upper and lower lips and pulling out the remainder of the wire gently During the period of fixation the patient must subsist on a fluid diet Frequent mouth washes are employed.

Open Reduction and Fixation of a Fractured Mandible is the method of choice in —

1 A fracture with a posterior edentulous fragment.
2. A fracture in an edentulous patient.
3. Bilateral fractures with insufficient teeth for intermaxillary wiring
4 Fractures in the immediate region of the mandibular symphysis.
5 When the mandible is fractured in more than one place.

Unless they are loose, broken, or carious, it is unnecessary to extract teeth in the neighbourhood of the fracture. The site of the fracture is exposed through a small transverse incision along the lower border of the jaw drill holes are placed 0·5 cm. from the lower border of the mandible, and soft stainless steel wire is used for approximating the fragments. Wiring by this method is being used more extensively than formerly in Britain and it is practised widely in the U.S.A. the results are excellent. The operation is performed under antibiotic cover which is continued until the wire is removed—usually four weeks after its insertion. The jaw is kept immobilized for three weeks by a bandage after that time the patient may have semi-solid food. As fractures of the jaw are usually compound into the mouth, it is surprising that serious infection does not occur more frequently

A woman of 45 was knocked down by a bicycle, striking her chin on the road. That she had fractured her mandible was clear but that it had been fractured in two places was less evident. She had been treated at home for ten days. By the end of this time there was obvious suppuration in the region of the angle of the jaw and also a second area of suppuration in the submental region. The radiograph showed a fracture at the angle, with gross displacement and a second fracture between the lateral incisor and canine teeth. An incision was made beneath the angle of the jaw and pus was evacuated. Through this incision the fragments were displayed and wired together leaving the ends of the wire protruding through the partially sutured wound. The anterior fracture was immobilized by passing a silver wire through the alveolus. Drainage of the submental region was effected by a simple incision.

Fractured Mandible with External Wound.—

B.A., aged 15, was brought to hospital with a lacerated wound of the skin through which protruded one segment of a completely fractured lower jaw The wound was grossly contaminated with road dirt. Under intravenous anaesthesia the wound was excised. A loose piece of alveolus and several teeth were removed. Two holes were drilled and the fractured surfaces were brought into apposition with a silver wire. The twisted ends of the wire were left jutting into the wound, which was sutured partially The wire was removed six weeks later But little suppuration occurred and excellent union resulted.

REDUCTION OF A DISLOCATION OF THE MANDIBLE

The Indirect Method is as follows —Bandage your thumbs, and over the bandage wind adhesive tape. The patient lies upon a couch and the operator stands behind the head. Insert the thumbs into the mouth so that their pulps lie on the molar area, while the fingers are insinuated around the angle of the jaw (*Fig* 1137) Very slowly exert pressure through the extended arms. This tires out the temporal and masseter muscles, and by depressing the back of the jaw and lifting the chin reduction can generally be accomplished. In difficult cases anaesthesia will be necessary.

Fig 1137 —The indirect method of reducing a dislocated mandible.

The Direct Method.—On the rare occasion when reduction is not easy and particularly when an incomplete replacement has been effected the direct method has proved most satisfactory The surgeon introduces his index finger (in bilateral cases, both index fingers) between the cheek and mandible to a point 1¼ in. (3 cm.) above the last molar tooth The coronary process is then palpated. Although this process is difficult to feel when the jaw is in its normal position, it is readily palpable in cases of dislocation. By gently pressing on the coronary process with the tip of finger or fingers in a backward and downward direction, the condyle slips into the mandibular fossa with ease

abscess of the brain and pulmonary embolism are frequent complications. Should the condition respond to treatment, the clot in the cavernous sinus becomes organized, and finally obliterated by fibrous tissue. Sometimes at a later date recanalization takes place.

The Primary Focus.—The sinister reputation of furuncles and carbuncles of the face is well known, and the great majority of the cases are due to this cause. Furuncle of the nose heads the list, while the upper lip, the cheek, and the eyelid contribute their quota. Middle-ear infections, once a frequent cause, now only constitute about [illegible] per cent of the total number of cases; dental infections are responsible for 7 per cent.

Diagnosis.—There is a latent period between the appearance of the primary lesion and signs indicating involvement of the sinus—usually about 5 days. The onset is acute, with a high temperature, extreme toxicity, with early semi-coma and delirium. Severe headache is a common symptom, and there is sometimes nausea and vomiting.

Ophthalmic Signs.—Œdema of the eyelids and the conjunctiva is manifest early, and later the swelling spreads to involve the whole of one side of the face. This is followed by progressive exophthalmos and evidence of involvement of the 3rd, 4th, the first and second divisions of the 5th and 6th cranial nerves. Thus a partial or complete ophthalmoplegia results, and the pupil is dilated and fixed. Vision is impaired or sometimes lost in the affected eye. Examination of the fundus reveals engorgement of the retinal veins and sometimes papillœdema. Clouding of the vitreous humour sometimes obscures these manifestations. A characteristic finding is the appearance of similar signs on the opposite side, which vary from œdema of the eyelids to all the signs enumerated. Septicæmia and meningitis usually follow and the blood-culture is frequently positive.

Differential Diagnosis.—Orbital cellulitis is the only condition likely to be confused with cavernous sinus thrombosis. The toxæmia is less, and what is of fundamental importance is that the signs are strictly unilateral. In doubtful cases where there is not a quick response to antibiotic therapy, an exploratory incision into the orbit should be made (see p. 1049).

Treatment.—Massive and prolonged *antibiotic therapy*[1] has brought this formerly almost invariably fatal condition into the realms of curability. The successful treatment rests on giving prodigious doses of the chosen antibiotic. Thus Rattner and Tytus administered 25 000 000 units of penicillin daily, with an abrupt change for the better. As improvement sets in the dose is reduced, but antibiotic therapy should be continued for two weeks after the subsidence of all local and general signs. When possible it is highly important that the organism be tested for its sensitivity to antibiotics; a number of penicillin-resistant staphylococci (which is the usual organism present) have been isolated in these lesions. Therefore, while awaiting the bacteriological report, it is best to administer terramycin, or penicillin combined with either streptomycin or aureomycin.

For the first week of treatment *anticoagulant therapy* (see p. 927) should be given in addition.

Mortality.—Owing to the tendency to report successful cases, it is difficult to assess accurately the present-day mortality of this condition. Of 14 recent cases collected by Rattner and Tytus, only 1 died.

Sequelæ.—Of these 14 cases, 5 had residual cranial nerve lesions, 1 suffered unilateral blindness, and 1 bilateral blindness. Thus it will be apparent that whereas formerly but few patients recovered, as a result of antibiotic therapy a large majority recover, but not a few of these have serious nerve lesions, including blindness. It behoves us, therefore, to take every step humanly possible to avoid this sinister complication.

WOUNDS OF THE TONGUE

Anterior Two-thirds.—Not infrequently a wound of the tongue is caused by a blow upon the chin at a time when the tongue is not fully retracted within the mouth. The patient himself biting the organ during return to consciousness from anæsthesia or during an epileptic seizure is another familiar cause of this accident.

In the anterior two-thirds hæmorrhage is arrested readily by pinching the tongue between finger and thumb behind the laceration; since the organ is slippery, a piece of gauze is employed in order to maintain a good hold. Once an efficient mouth-gag is in place and a good hold of the organ has been obtained the repair of these lacerations with catgut stitches presents no difficulty. "Even if the segment be almost completely separated,

[1] For the first 48 hours an intravenous antibiotic, e.g. one of the tetracycline group can with advantage be given in a continuous dextrose-saline drip, as also the anticoagulant therapy.

so that it is attached by nothing more than a thread of muscular or mucous tissue it should be sutured to the stump in the hope which is not in vain of preserving it (Sir Henry Butlin).

Posterior Third.—Wounds of the back of the tongue are rare As a first-aid measure for controlling severe bleeding from this situation, Heath instructed that the index finger should be passed right back to the root of the tongue and then hooked so that the whole organ is compressed against the mandible In cases of inaccessible wounds of the tongue one should have no hesitation in performing tracheostomy under local analgesia. After plugging the pharynx, usually the wound can be properly repaired with deep stitches that will at the same time control hæmorrhage : generally local analgesia is to be preferred, and it is surprisingly satisfactory

Wounds of the tongue heal readily though swelling and inflammation are present in the early stages.

ACUTE GLOSSITIS

Acute glossitis is a rare condition. As they are both instructive two cases will be quoted.

Case 1.—Mrs. W., aged 70, had Ludwig's angina, and was treated as described on p. 844 by decompressing the mylohyoid under which two drachms of pus were found. Next morning she was much better That evening I was summoned hastily for her tongue had become so large in the space of half an hour that it protruded considerably from the mouth, and the house surgeon considered that tracheostomy would be necessary The patient was salivating profusely but it was found that when she lay on her side and a piece of gauze was tucked into the dependent corner of her mouth, the saliva ran away and this lessened the feeling of impending suffocation. The tongue was coated with paraffin, she was fed by means of a trans-nasal gastric tube and in forty eight hours her tongue had receded within the mouth.

Case 2.—A girl, aged 10 was brought to hospital with her tongue protruding fully 1½ in. from her mouth. Her mother stated that the trouble began two days previously and that she had had a similar attack three years before The temperature was 103° and the pulse 130. There was a herpetiform eruption on the tip of the tongue and some membrane not unlike diphtheritic membrane under the tongue The submaxillary lymph-nodes on both sides were enlarged and tender A piece of the membrane was removed and sent for bacteriological examination, and the unexpected report was returned—"Vincent's spirillum" Treatment was undertaken by painting the tongue with N.A.B. solution. Within three days the condition had cleared up.

These cases demonstrate that success may attend expectant treatment, but one must be prepared to perform tracheostomy should respiration become dangerously difficult Antibiotic therapy should be commenced forthwith.

It is seldom that a summer passes without a case of fatal wasp sting of the tongue being reported in the newspapers. Typically a picnicker quaffs beverage from a bottle that has been left open. In such circumstances stab laryngostomy with a penknife for an adult, or desperately urgent tracheostomy for a child are the only means of averting asphyxia.

ABSCESS OF THE TONGUE

In a case of a deep abscess of the tongue with acute symptoms, I thrust a pair of sinus forceps into the abscess cavity from the under surface of the tongue. The method proved satisfactory In this, and another case where the abscess was opened by an incision through the dorsum milder symptoms recurred within a few months. In both cases what was believed to be a dermoid cyst was dissected out of the interior of the split tongue. No epithelium was found in the wall.

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Case 2.—A girl, aged 10 was brought to hospital with her tongue protruding fully 1½ in. from her mouth. Her mother stated that the trouble began two days previously and that she had had a similar attack three years before. The temperature was 102° and the pulse 130. There was a herpetiform eruption on the tip of the tongue and some membrane not unlike diphtheritic membrane under the tongue. The submaxillary lymph-nodes on both sides were enlarged and tender A piece of the membrane was removed and sent for bacteriological examination, and the unexpected report was returned—"Vincent's spirillum" Treatment was undertaken by painting the tongue with N.A.B. solution. Within three days the condition had cleared up.

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abscess of the brain and pulmonary embolism are frequent complications. Should the condition respond to treatment, the clot in the cavernous sinus becomes organized and finally obliterated by fibrous tissue. Sometimes at a later date recanalization takes place.

The Primary Focus.—The sinister reputation of furuncles and carbuncles of the face is well known, and the great majority of the cases are due to this cause. Furuncle of the nose heads the list, while the upper lip, the cheek, and the eyelid contribute their quota. Middle-ear infections, once a frequent cause, now only constitute about 8 per cent of the total number of cases; dental infections are responsible for 7 per cent.

Diagnosis.—There is a latent period between the appearance of the primary lesion and signs indicating involvement of the sinus—usually about 5 days. The onset is acute with a high temperature, extreme toxicity, with early semi-coma and delirium. Severe headache is a common symptom, and there is sometimes nausea and vomiting.

Ophthalmic Signs.—Œdema of the eyelids and the conjunctiva is manifest early and later the swelling spreads to involve the whole of one side of the face. This is followed by progressive exophthalmos and evidence of involvement of the 3rd, 4th, the first and second divisions of the 5th and 6th cranial nerves. Thus a partial or complete ophthalmoplegia results, and the pupil is dilated and fixed. Vision is impaired or sometimes lost in the affected eye. Examination of the fundus reveals engorgement of the retinal veins and sometimes papillœdema. Clouding of the vitreous humour sometimes obscures these manifestations. A characteristic finding is the appearance of similar signs on the opposite side, which vary from œdema of the eyelids to all the signs enumerated. Septicæmia and meningitis usually follow and the blood-culture is frequently positive.

Differential Diagnosis.—Orbital cellulitis is the only condition likely to be confused with cavernous sinus thrombosis. The toxæmia is less, and what is of fundamental importance is that the signs are strictly unilateral. In doubtful cases where there is not a quick response to antibiotic therapy, an exploratory incision into the orbit should be made (see p. 1049).

Treatment.—Massive and prolonged *antibiotic therapy*[1] has brought this formerly almost invariably fatal condition into the realms of curability. The successful treatment rests on giving prodigious doses of the chosen antibiotic. Thus Rattner and Tytus administered 25 000 000 units of penicillin daily, with an abrupt change for the better. As improvement sets in the dose is reduced, but antibiotic therapy should be continued for two weeks after the subsidence of all local and general signs. When possible it is highly important that the organism be tested for its sensitivity to antibiotics; a number of penicillin-resistant staphylococci (which is the usual organism present) have been isolated in these lesions. Therefore, while awaiting the bacteriological report, it is best to administer terramycin, or penicillin combined with either streptomycin or aureomycin.

For the first week of treatment *anticoagulant therapy* (see p. 027) should be given in addition.

Mortality.—Owing to the tendency to report successful cases, it is difficult to assess accurately the present-day mortality of this condition. Of 14 recent cases collected by Rattner and Tytus, only 1 died.

Sequelæ.—Of these 14 cases, 3 had residual cranial nerve lesions, 1 suffered unilateral blindness, and 1 bilateral blindness. Thus it will be apparent that whereas formerly but few patients recovered, as a result of antibiotic therapy a large majority recover, but not a few of these have serious nerve lesions, including blindness. It behoves us, therefore, to take every step humanly possible to avoid this sinister complication.

WOUNDS OF THE TONGUE

Anterior Two-thirds.—Not infrequently a wound of the tongue is caused by a blow upon the chin at a time when the tongue is not fully retracted within the mouth. The patient himself biting the organ during return to consciousness from anæsthesia or during an epileptic seizure is *another familiar cause of this accident.*

In the anterior two-thirds hæmorrhage is arrested readily by pinching the tongue between finger and thumb behind the laceration; since the organ is slippery, a piece of gauze is employed in order to maintain a good hold. Once an efficient mouth-gag is in place and a good hold of the organ has been obtained the repair of these lacerations with catgut stitches presents no difficulty. "Even if the segment be almost completely separated,

[1] For the first 48 hours an intravenous antibiotic, e.g. one of the tetracycline group, can with advantage be given in a continuous dextrose-saline drip, as also the anticoagulant therapy.

so that it is attached by nothing more than a thread of muscular or mucous tissue, it should be sutured to the stump in the hope, which is not in vain of preserving it" (Sir Henry Butlin)

Posterior Third.—Wounds of the back of the tongue are rare As a first-aid measure for controlling severe bleeding from this situation, Heath instructed that the index finger should be passed right back to the root of the tongue and then hooked so that the whole organ is compressed against the mandible In cases of inaccessible wounds of the tongue one should have no hesitation in performing tracheostomy under local analgesia. After plugging the pharynx, usually the wound can be properly repaired with deep stitches that will at the same time control hæmorrhage: generally local analgesia is to be preferred, and it is surprisingly satisfactory

Wounds of the tongue heal readily though swelling and inflammation are present in the early stages.

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CHAPTER LXVII

EMERGENCIES CONNECTED WITH THE TEETH

TRISMUS

SEVERE trismus is liable to complicate inflammatory processes involving the muscles of mastication.

Diagnosis.—To arrive at a conclusion as to the cause of trismus is not always an easy matter. The first duty is to eliminate tetanus (*see* p. 128). Next consider the possibility of infection of the masticator space (*see* p. 847). Thirdly concentrate on the establishment of a confident diagnosis of mal-eruption of a mandibular wisdom tooth. This is by far the commonest cause. A history of neuralgic toothache, unmistakable foetor, tenderness of the posterior part of the alveolus when the finger is insinuated along the lower gum as far as possible, and tender enlargement of the submaxillary lymph nodes, when present together make the diagnosis extremely probable, but a radiograph is required to confirm that an impacted third mandibular molar is present.

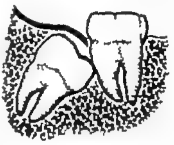

Fig. 1147.—An operculum over a mal-erupted wisdom tooth.

Management.—It is unfortunate that trismus prevents an examination of the region we so much desire to see and palpate. In the majority of cases the cause of the trouble is an operculum—a flap of gum (*Fig.* 1147) that harbours putrefying food particles beneath it. Sometimes beneath the intact, or almost intact, gum there is a pericoronal abscess that requires free drainage. If the temperature is not above 100° F. (37.8° C.) and the patient's general condition is good, it is permissible to assume that this is the cause, always with the reservation that a peri-apical abscess may be present which, in point of fact, calls for early extraction of the impacted tooth if serious complications are to be avoided (*see* p. 831).

Fig. 1148.—Clothes-pegs are useful for maintaining continuous pressure on the jaw in trismus.

The Temperature is below 100° *F.* (37.8° *C.*).—Antibiotic therapy (penicillin and streptomycin) and the injection of morphine if the pain is severe, is given. The aim is to prise open the jaw gradually. For this purpose a common clothes-peg is useful. The ends of the clothes-peg are whittled down with a knife so as to take the form of a wedge. It is always possible to separate the jaws for a millimetre or two, and the end of the wedge is firmly pressed between the front teeth. The peg is left in position for hours at a stretch, and by its continual pressure the amount of separation increases. As soon as there is about a ¼ in. (6 mm.) of separation, a clothes-peg of the spring type (*Fig.* 1148) is substituted. A transverse notch is cut on either side to accommodate the edges of the incisors. The peg is left in position for long periods, and gradually but surely the amount of separation increases.

As soon as the mouth can be opened sufficiently and an operculum with an adequate orifice is seen to be present, syringeing beneath the flap with a fine dental syringe must be carried out at frequent intervals, and hourly mouth-washes are ordered. Should the opening be comparatively small, or a closed pericoronal abscess be present, the patient must be anæsthetized and the flap excised or, if a closed abscess is present, it is incised. As soon as the inflammation has abated, removal of the impacted wisdom tooth must be carried out.

The Temperature is above 100° *F.*—*When there is a severe general reaction the course outlined above carries too many risks for it to be followed. Perhaps when the services

of a skilled anæsthetist are available having taken the precaution of aspirating the contents of the stomach, it is wisest to anæsthetize the patient in *every* case. Under the anæsthetic the mouth can be opened, and kept open by leaving in a mouth-prop (*Fig* 1149) then from the very start a satisfactory diagnosis can be made. If there is an operculum present, treatment can be commenced at once If there is a pericoronal abscess or insufficient drainage that can be remedied. But what is to be done if neither of these is present, and there is almost certainly a peri-apical abscess of a mal-erupted wisdom tooth? It should be realized that no help in the diagnosis of peri-apical abscess can be expected from the radiograph unless the abscess is of more than a week's duration. If the operator has not the correct instruments and the knowledge how to remove an impacted third molar (see p. 834) it is adviseable to continue with antibiotic therapy until the services of a dental surgeon are available.

Sc 2/3

Fig 1149.—Airway and mouth-prop (London Ho pit) pattern).

HÆMORRHAGE AFTER EXTRACTION OF TEETH

Severe or continued hæmorrhage after tooth extraction is a common emergency In such cases one rightly suspects, and endeavours to elicit, the history of a hæmorrhagic diathesis, but in the majority of instances the continued hæmorrhage is not due to hæmophilia. Within the tooth socket there is an open vessel which, in more accessible situations, would have warranted ligation in the first instance. Furthermore, it is probable that the bony alveolus has been fractured and occasionally there is a piece of bone loose in the socket. The latter prevents contraction of the wound, and may be the cause of the continued bleeding

Management.— Sit the patient bolt upright and syringe out the socket. Take two pairs of dissecting forceps and a quantity of small gauze pledgets. Open the mouth widely with a mouth-gag and instruct the patient to keep his tongue still Gently mop away the blood and blood-clot from the socket with one pair of forceps and with the other turn back the mucoperiosteum. Ascertain if there is a loose fragment of bone which can be removed. Even attached spicules of bone can prevent closure, and when such are present they should be removed with bone forceps.

Demonstrate the location of the bleeding vessel. Pick up a pledget of gauze in one forceps and with it apply lateral pressure to the soft tissues of the socket. With gauze in the other forceps mop the cavity dry Proceed in the same way applying pressure on the other side of the socket Usually it can be demonstrated that pressure on one or other lateral wall stops the hæmorrhage.

If a piece of bone has been removed, all that may be necessary is to continue pressure here for a few moments and then to improvise a method for keeping up this pressure. For instance a small roll of gauze may be inserted, and upon this the patient closes his jaws and a four tailed bandage keeps the parts at rest. At other times, when the bleeding is from the lingual side a mop of gauze is tied on the end of a blunt object, such as the handle of an aneurysm needle, and the patient himself keeps up this pressure for half an hour

Styptics.—The local application of snake venom (stypven) may be tried many dental surgeons consider that liquor ferri perchlor is an even better styptic. Torney gives the following instructions A hard tampon of cotton-wool, about the size of the root socket, is put into a liquid made up of equal parts of liquor ferri perchlor liquor hydrarg perchlor., and glycerin. It is then dipped into tannic acid powder and pressed firmly into the socket being kept in situ for a few minutes with the end of the finger and left in for twenty-four hours. The patient is given strict instructions: (*a*) to refrain from using mouth-washes, (*b*) not to suck the tooth socket

Absorbable hæmostatics.—While the ordinary absorbable gauze or gelatin sponge used in surgery can be employed a special gelatin sponge for dental use is manufactured. It is gelatin sponge impregnated with 0 1 per cent dequadin chloride[1] As a prophylactic measure small pieces of this substance are inserted into the socket immediately after extraction and covered with a gauze pack on which the patient bites. When it is necessary to suture the gums pieces of this sponge are inserted into the socket after the suture has been placed but before it is tied.

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[1] Allen & Hanburys Ltd., Bethnal Green, London E.2.

If these measures fail or it is judged that they are unlikely to succeed, there is the choice of two methods of securing hæmostasis.

1 *Suture of the Gums.*—This is sometimes efficacious, but unless the sharp edges of the alveolus are removed there is often too little tissue to take a suture especially as the gum is notoriously friable Procaine infiltration may be used, but generally the patient, exhausted by many attempts to stop the hæmorrhage is apprehensive of the injection and thiopentone anæsthesia is to be preferred. Using a fine curved needle on a holder a

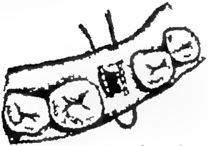

Fig 1130 —Method of suturing the gums.

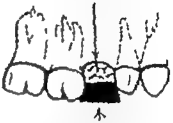

Fig 1131 —The "stopper" method of controlling persistent hæmorrhage from a bleeding tooth socket

mattress suture is passed as shown in *Fig* 1130 and tied. The loop should be on the side from which the bleeding has been demonstrated to occur the knot falling on the opposite side

2. *The Stopper Method*—A small piece of dental composition is heated in boiling water partially cooled, and pressed into the socket. On removing and chilling this will form a plug to fit the socket exactly This is then applied as shown in *Fig* 1131 the gauze can be moistened with snake venom with advantage.

The patient closes his jaws upon the stopper and a four tailed bandage completes the procedure After about twelve hours the stopper and dressing are removed. The method is a good one, but it is somewhat limited in its application, for there must be a sound, or at least substantial, tooth on either side of the bleeding socket.

Bleeding due to Hæmophilia.—Although not to be recommended unless the agents specified on p. 68 are not obtainable quickly I have treated three male patients, aged 30, 24 and 21 respectively each with a well marked history of hæmophilia admitted after tooth extraction because of continued hæmorrhage All were dealt with in the same way Twenty ml (6 dr) of fresh alien blood was injected into the rectus abdominis muscle. In one case this was combined with the stopper described above In each case the hæmorrhage ceased within a few hours. The prevention and treatment of hæmorrhage due to hæmophilia is discussed on p. 68

Renewed Hæmorrhage.—Very rarely hæmorrhage recommences after all the foregoing efforts to check it permanently Blood transfusion will be indicated if it has not become necessary before this time. The bleeding and coagulation time of the blood should be taken as a matter of routine in all cases of persistent bleeding.

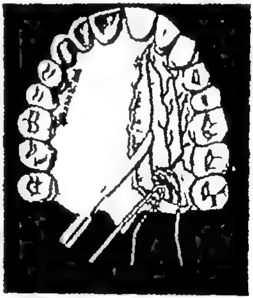

Fig 1132.—Ligature of the posterior palatine artery (*After S L. Silverman*)

In dealing with cases of persistent bleeding one should realize that ligation of the external carotid artery is futile In the case of the upper jaw (usually the seat of this troublesome complication) S. L. Silverman recommends, and has practised successfully ligation of the posterior palatine artery The vessel must be exposed at its exit from the posterior palatine foramen. This is accomplished by lifting up the mucoperiosteum from the bon

with a periosteal elevator using the knife as little as possible. The vessels are identified easily as they emerge from the foramen, and they can be stretched sufficiently to insert a ligature beneath without fear of rupture (*Fig* 1152). Alternatively a boiled match-stalk could be driven into the posterior palatine foramen, but ligature is to be preferred. The flap is not sewn, but held roughly in position by a swab on a holder until a temporary dental plate can be made to keep it in position.

PULPITIS

Usually pulpitis, commonly known as toothache, is caused by inflammation of the nerve in the pulp due to bacterial invasion through a cavity in the outer hard structures of the tooth. Pain is severe and throbbing It tends to increase when the patient lies down, and is accentuated by thermal changes, particularly cold. Tapping the tooth does not increase the pain.

Emergency Treatment.—After the patient has rinsed his mouth thoroughly with warm saline solution the operator should enlarge the cavity by chipping away the undermined shell of enamel. Débris is removed by syringeing the cavity gently with warm saline solution. The area is then isolated with cotton wool rolls and the cavity dried A pledget of cotton-wool moistened with dentalone,[1] eugenol,[2] or oil of cloves is inserted into the cavity The dressing is sealed with warmed gutta percha. The dressing should be changed as often as is necessary to control pain, but as soon as arrangements can be made the patient should be referred to a dental surgeon.

ACUTE PERI APICAL ABSCESS

Diagnosis.—In the early stages of acute periodontitis discomfort is experienced in the region of the affected tooth, which feels elongated so that the patient complains that he bites on it before the other teeth. When suppuration supervenes and pus is confined in the bone the pain is intense. Heat, e.g hot water will increase the pain, owing to expansion of gases in the pulp chamber Tapping the affected tooth also increases the pain.

Radiography —As it takes from 7 to 10 days before sufficient resorption of bone occurs for radiographic signs of peri-apical abscess to become apparent, no help can be expected from radiography in the diagnosis of acute peri apical abscess.

Treatment.—Early extraction of the tooth will bring relief and obviate further complications. In these circumstances the extraction should always be carried out under antibiotic cover and general anæsthesia is advisable If the tooth is one that it is desirable to conserve for cosmetic reasons, a dental surgeon may be able to drain the abscess via the apical canal and preserve the tooth at least temporarily

Stage of Cellulitis.—When there is swelling of the surrounding parts and hyperæmia of the gum extraction should not be performed for the time being Antibiotic therapy is given and should be continued until the inflammation has abated and the temperature is normal or until an alveolar abscess requiring drainage is present. Mouth-washes are ordered, but hot fomentations and poultices of any kind should be avoided, for they tend to favour pointing of an alveolar abscess externally

ALVEOLAR ABSCESS

While an acute alveolar abscess can occur at any time of life it is mainly a disease of childhood and early adult life In as far as the second dentition is concerned alveolar abscesses arise with greater frequency in connexion with the mandibular than the maxillary teeth, the mandibular molars, particularly the first molar being the most commonly affected. On the other hand, in the deciduous dentition infection is distributed almost equally between the upper and lower jaws, and is restricted mainly to the molar teeth.

Like any other acute abscess, a peri-apical abscess tends to point along the line of least resistance which is governed by local anatomy The various directions taken by the pus are in order of frequency as follows :—

a Through the lateral surface of the bone This is the most common path because the roots are more frequently nearer to this side In the molar region of either jaw this occurs

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[1] Dentalone (Parke Davis & Co Ltd), is a saturated solution of chlorotone in a mixture containing oil of cloves.

[2] Eugenol is the active principle of oil of cloves.

perforation can occur above (*Fig* 1153 *a*) or below (*Fig* 1153 *b*) the attachment of the buccinator muscle and on this depends whether there results a swollen face or a gum-boil.

b Through the medial surface. This occurs when the root of a tooth is near the medial plate of bone and in the upper jaw it leads to a palatal abscess. In the lower jaw the pus perforates the bone either below (*Fig* 1153 *c*) or above the attachment of the mylohyoid muscle

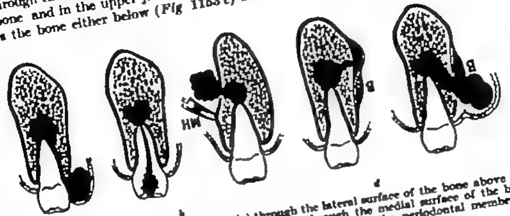

Fig 1153.—Alveolar abscesses arising (*a*) through the lateral surface of the bone above the buccinator muscle; (*b*) ditto below that muscle; (*c*) through the medial surface of the bone below the mylohyoid (*d*) through the root canal; (*e*) through the periodontal membrane B, Buccinator muscle; MH, Mylohyoid muscle (*After H H Stones*)

c. Sometimes the pus discharges through the root canal into the cavity of the tooth (*Fig* 1153 *d*) and from thence into the mouth.

d. Occasionally the pus tracks through the periodontal membrane, and points beneath the gingival sulcus (*Fig* 1153 *e*). This route is followed mainly in connexion with teeth of the first dentition the anchorage of which is less firm than that of the permanent dentition.

e Rarely pus is evacuated into the maxillary antrum from a root of a tooth related to its floor most frequently the first permanent molar

f Very rarely pus points beneath the floor of the nasal fossa from an abscess of a first upper incisor tooth. The alveolar abscess beset with the most dangerous complications is one connected with a third mandibular molar tooth (*Fig* 1154).

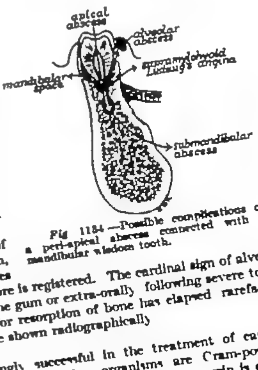

Fig 1154.—Possible complications of a peri-apical abscess connected with a mandibular wisdom tooth.

Diagnosis.—When the pus breaks through the alveolar bone and its periosteum which as a rule takes several days, the intense pain of a peri apical abscess is relieved. If the muscles of mastication are involved in the inflammation, trismus occurs. In over 40 per cent of cases a peak temperature of 102° F (38 9 C.) or more is registered. The cardinal sign of alveolar abscess is a fluctuating swelling situated on the gum or extra-orally following severe toothache If sufficient time (10 or more days) for resorption of bone has elapsed rarefaction around the apex of the affected tooth will be shown radiographically

Treatment.—

Antibiotic Therapy has proved amazingly successful in the treatment of cases of alveolar abscess. With rare exceptions, the infecting organisms are Gram-positive consequently penicillin is the antibiotic usually employed, although aureomycin is equally effective The temperature chart is a reliable and accurate index of the patient's progress under this treatment Reduction in the temperature usually heralds a favourable outcome Within 48 hours the swelling abates and the pain diminishes. In over 30 per cent of cases resolution follows, permitting the offending tooth to be extracted in the quiescent stage

Physical Agents.—Although they are still useful adjuncts, the role of physical agents are subsidiary to antibiotic therapy Cold external applications and hot intra-oral irrigations are recommended hot fomentations are applied only when external incision seems inevitable

DRAINAGE OF AN ALVEOLAR ABSCESS

a **Into the Mouth.**—When a cystic swelling is present in relation to the gum, the abscess should be opened into the mouth by incising the periosteum. It should be noted that the periosteum must be incised. The incision is made either on the labial (*Fig* 1155) or on the lingual side of the alveolus as the physical signs dictate The point of the knife is carried down to the bone and the cut is made parallel to the alveolus. In exceptional cases when a flow of pus is not obtained the incision in the case of the lower jaw is converted into a + on the labial side on the lingual side, however a ⊥ only is used, for a downward stroke of the knife below the first cut would endanger structures on the floor of the mouth notably the lingual nerve In the case of the upper jaw if necessary the incision is enlarged cautiously particularly in an upward direction, with the points of a hæmostat. When a drainage tube is thought to be necessary—and this will be the case in the upper jaw with a pocket of pus running upwards towards the malar bone—a self retaining tube (*Fig* 1156) will be of service The after treatment consists of hot antiseptic mouth-washes and a continuance of antibiotic therapy

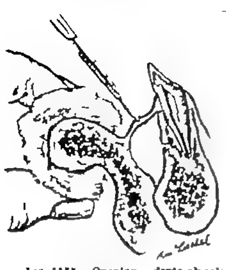

Fig 1155.—Opening dento-alveolar abscess. The incision should be made parallel with the alveolar margin

At the Mount Sinai Hospital, New York of 202 cases of alveolar abscess in which drainage was required 154 (77 per cent) were drained intra-orally while in 31 cases rupture took place into the mouth spontaneously

b **Extra-oral Drainage.**—If the case is first seen when the abscess is pointing externally or if internal drainage has failed—a rare event—then an external incision must be made When possible design this incision to lie in the shadow of the jaw by making it ½ in. (1 3 cm.) below the lower border of the mandible the facial (external maxillary) artery and the mandibular branch of the facial nerve will be avoided (*Fig* 1157) Of 48 cases requiring extra-oral incision, maxillary infection accounted for only 5 (Elsenbud and Klatell)

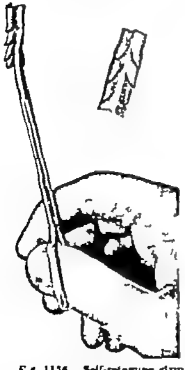

Fig. 1156.—Self-retaining strip of corrugated rubber The imbricated openings are made by cuts with scissors. It is inserted in the manner shown.

Fig 1157—Incisions for draining an alveolar abscess externally

c **Drainage by Extraction of the Offending Tooth.**—In the primary dentition extraction is an acceptable and generally successful procedure of draining an alveolar abscess. With alveolar abscesses connected with the permanent dentition a cure is less likely to result through extraction alone Moreover even if the extraction is performed under antibiotic cover there is a possibility of causing an extension of the inflammatory

process in the soft parts and sometimes engendering osteomyelitis of the jaw. In the case of the maxilla, thrombosis of the cavernous sinus has followed this procedure (R. Grant). Therefore in general it may be stated with assurance that in the case of an alveolar abscess connected with a *permanent* tooth it is far better to drain the abscess by an appropriate incision, and to postpone extraction of the offending tooth until 10 days after the inflammatory process has abated.

POST-EXTRACTION ALVEOLAR ABSCESS

Infection may or may not have been present in the pulp chamber of the recently extracted tooth: if not, it is possible that the infection was implanted during extraction. One should be mindful of the legal implications of an allegation of the latter source of infection. Unless the extracted tooth, or a swab from the socket, was sent for bacteriological examination and a positive report obtained, it is apparent that the allegation is difficult to disprove.

Of 800 patients with alveolar abscess requiring hospitalization, in 33 the abscess followed dental extraction and 40 per cent of these pointed extra-orally (Eisenbud and Klatell): *post-extraction infection is inclined to be more invasive than a primary abscess.*

LOCAL ANÆSTHESIA FOR DENTAL EXTRACTION

Local infiltration is contra-indicated in the presence of obvious signs of infection of the gum; in other circumstances it is highly satisfactory.

Local Infiltration Anæsthesia.—All teeth except the mandibular molars can be anæsthetized by injecting 1–2 ml. of 2 per cent procaine, or preferably 2 per cent lignocaine, through a 20 mm. 25-gauge needle around the labial and the lingual sides of the root. The labial side is injected first, and the mucous membrane is pierced at its reflexion from the gum (*Fig.* 1158). The point of the needle is advanced until its tip is judged to lie over the apex of the root. Its point is withdrawn from under the periosteum, and injection of 1 ml. of the solution will raise a weal. The injection is repeated on the lingual side of the tooth. After waiting for about five minutes, test for anæsthesia by *prodding* the gum on either side of the tooth. If it is painful, inject more solution.

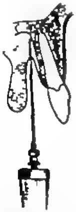

Fig. 1158.—Site of local infiltration on the labial side of the tooth. (*After E. Joseph.*)

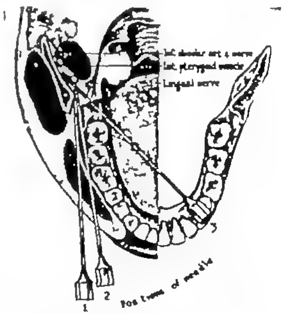

Fig. 1159.—Progressive positions of the needle for nerve-block of the third division of the 5th cranial nerve.

Regional Block Anæsthesia.—In the case of mandibular teeth, block anæsthesia is *more effective than infiltration anæsthesia* because the cortical bone is too dense to permit penetration of local anæsthesia by infiltration. The third division of the 5th cranial nerve is injected in the mandibular sulcus before it enters the mandibular foramen. A 42-*mm* 20- or 23-gauge needle is employed. The point of injection is the centre of the retromolar fossa, which is bounded externally by the anterior border of the ramus and internally by

the internal pterygoid muscle The mucous membrane over the fossa is infiltrated with the anæsthetic solution, and the needle is advanced. The three progressive positions of the needle are shown in *Fig* 1159 When the second position is reached ½ ml. of procaine is injected to anæsthetize the lingual nerve. The needle is then advanced to the third position, where 1½ ml. of procaine is injected to anæsthetize the inferior dental nerve. When anæsthesia of the inferior dental nerve has been accomplished it will be evinced by a numb lower lip on that side Next the mucous membrane on the labial aspect of the gum must be anæsthetized by a separate injection of the buccinator nerve in the inferior labiobuccal fold just posterior to the tooth to be extracted After waiting about five minutes, the extraction can be performed without pain.

EXTRACTION OF TEETH

The occasional dental operator will do well to visualize the anatomical conformation of the roots of the tooth he is about to extract In this connexion *Fig* 1160 will prove useful.

It is, of course desirable to be able to choose the forceps (*Fig* 1161) suitable for the particular tooth to be extracted. For example the handles of the forceps used for extracting the upper molars are cranked to varying degrees, in order to avoid obstruction against the lower teeth. Similarly to allow the operator to work in a suitable position, all forceps used for extracting the lower teeth are set in a plane at right angles to their handles. In spite of these desiderata, if need be the only instruments that are absolutely essential for dental extractions are those depicted in *Fig* 1162.

TECHNIQUE OF EXTRACTION

When extracting a tooth in the lower right quadrant of the mouth the operator should stand behind and to the right of the patient. Teeth in other segments of the mouth must be extracted with the operator standing in front of the patient. The operator's left hand grasps the tooth between the forefinger and thumb these digits act as a guide and prevent the forceps from slipping during their application. They also provide information about the movement of the tooth during extraction.

Application of Forceps.—Caries often undermines the crown more than is apparent clinically ; therefore when extracting, never grip the crown. The forceps should engage the proximal part of the root and to this end the blades of dental forceps have sharp edges so that they can be forced through the periodontal membrane and between the tooth and the bony alveolus for a certain distance The crown, however weak should guide the forceps into their proper position for extraction In every case one blade of the forceps should first be placed upon the palatal or lingual side of the tooth. Having lightly grasped the tooth in the jaws of the instrument (*Fig* 1163) the beak is pushed upwards or downwards as far as possible care being taken to avoid inclusion of the gum or alveolar process. Thus a firm grasp of the root of the tooth is obtained.

Loosening the Tooth from its Socket.—Extraction of a tooth must never be attempted by a straight pull. Successful extraction does not depend on the strength of the operator but upon the application of force in a definite manner so as to break the attachments of the root or roots from investing tissues. The tooth must be worked in the correct direction (*see below*) with a force that is increased gradually as the operator feels the supporting structures giving way

EXTRACTION OF INDIVIDUAL TEETH

Upper Central and Lateral Incisors.—The roots are roughly circular in cross-section ; therefore to sever their attachments these teeth should be rotated about their long axis, and then extracted by drawing them downwards vertically Use upper straight forceps.

Upper Canines are often triangular in cross-section therefore they resist rotation. Cautiously loosen in a buccal direction and then draw downwards vertically These teeth have the longest root of the whole dentition. Use heavy straight forceps.

Upper Pre molars—The first upper pre-molar often has two roots the second only one They are loosened in a buccal direction by a rocking movement and at the same time drawn downwards. Use moderately cranked upper forceps.

EXTRACTION OF TEETH

Fig. 1160.—The permanent teeth of the left side of the maxilla and mandible. 1, Central incisors; 2, Lateral incisors; 3, Canines; 4, 5, Premolars; 6, 7, 8, Molars. (*The late Mr. Alfred Coleman.*)

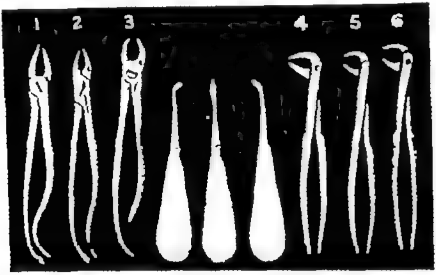

Fig. 1161.—A set of dental forceps and elevators. 1, Upper straight forceps; 2, Moderately cranked upper forceps; 3, Well-cranked upper forceps; 4, Lower forceps (narrow blades); 5, Lower forceps (medium blades); 6, Lower forceps (wide blades).

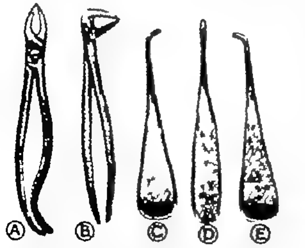

Fig. 1162.—The only absolutely necessary instruments required to extract any tooth. A, Universal upper forceps; B, Hawk-bill universal lower forceps; C, Right curved elevator; D, Straight elevator for removal of impacted third molar; E, Left curved elevator.

Fig. 1163.—Method of holding dental forceps.

Upper Molars.—Usually the first and second upper molars have three roots. In the case of the third molar two or more of these roots are fused. The inner beak of the forceps should be placed between the alveolus and the single palatal root. The outer beak is insinuated between the alveolus and the stronger of the two buccal roots. *It should never be placed between these roots,* or the tooth will break. Extract in the same manner as for premolars, using well-cranked upper forceps.

Lower Central and Lateral Incisors are triangular on cross-section. They are loosened by rocking in a buccal direction where the alveolus is relatively frail. They are extracted in an upward and labial direction Use lower forceps with narrow blades.

Lower Canines are also often triangular in section. They are loosened by labiolingual movement with the greater force exerted labially Use lower forceps with medium-sized blades.

Lower Premolars —As a rule the roots of these teeth are circular in cross-section, *therefore they can be loosened by rotation about their long axis, and removed vertically* Use lower forceps with medium-sized blades.

Lower Molars have two roots and are loosened by labiolingual movement. Usually a fully erupted lower third molar is removed towards the lingual side because of the thick labial plate of bone Use lower forceps with wide blades.

The Use of Elevators.—These are employed in extracting difficult lower molars and roots, and prove extremely useful at times.

The *straight elevator* is inserted between the tooth to be extracted and its neighbour and the flat blade is pushed between the tooth and the alveolar margin as far as possible The handle is then depressed, which tends to elevate the tooth. It often requires several of these movements before the tooth is loosened. The tooth should be held firmly with the thumb and forefinger during the operation, to prevent it accidentally slipping down the throat. When the tooth is loosened lower forceps are used to remove it.

The *curved elevator* is used to remove broken roots. Pass the elevator into the empty socket and elevate the root by forcing the point of the elevator through the septum of bone (*Fig* 1104).

Removal of an Impacted Mandibular Third Molar Tooth.—Vertical impaction is the most usual variety First reflect the gum-flap usually it is necessary to chisel away a

Fig 1104 —Employing a curved elevator to remove a broken root in the lower jaw

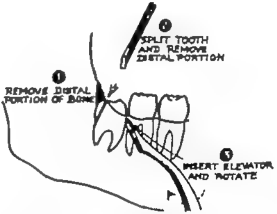

Fig 1103 —Steps in the removal of vertically impacted third mandibular molar (*After H H Stones.*)

fair amount of bone to uncover the distal part of the crown (*Fig* 1103 1). This accomplished, the distal part of the tooth is split from the remainder with a chisel (*Fig* 1103, 2): it is advisable to make a groove in the crown with a burr before the chisel is applied. By means of a straight elevator an elevator with a transversely set handle is an advantage—the larger fragment is extracted (*Fig* 1103 3). The removal of the smaller fragment by means of an elevator is a simple matter

In cases of vertical impaction should the second molar tooth be carious, by extracting that tooth room may be afforded for the impacted wisdom tooth to erupt.

Removal of a Horizontally impacted Mandibular Third Molar Tooth.—The best method of procedure in this often difficult operation is to uncover the tooth by reflecting a flap and chiselling away the overlying bone, as directed above The *second* molar tooth is then extracted. A transverse groove is cut in the crown and the tooth is split in its long axis, viz.

The upper portion can then be removed without difficulty , the remaining portion is removed with a straight elevator

In all cases extraction of an impacted wisdom tooth should be carried out under antibiotic cover If the gum is in an inflamed state pre-operative antibiotic therapy for at least 48 hours is advised.

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CHAPTER LXXIII

THE NECK

TRACHEOSTOMY

In cases of laryngeal obstruction never give morphine. A patient under the influence of morphine stops fighting for breath, seems peaceful, and not infrequently the nurse returns to find him dead. (Chevalier Jackson.)

TRACHEOSTOMY is required urgently for laryngeal obstruction due to diphtheria, œdema of the glottis, acute laryngo-tracheobronchitis in children not responding quickly to antibiotic therapy, bilateral abductor paralysis of the vocal cords following thyroidectomy, incised wounds of the larynx or trachea, a foreign body in the larynx, or inhaled vomitus. In the last the only hope of saving the patient's life is to apply suction through the tracheostomy opening, and to persevere with this expedient, combined with massive antibiotic therapy.

In recent years the indications for the operation have been extended, and it is now an integral part of the management of cases of unconsciousness complicating head injuries and facio-maxillary fractures, or coma from any cause that has persisted for more than a few hours where it is difficult to maintain a free airway.[1] It is also of signal value in patients suffering from tetanus, many of whom are (rightly) grossly sedated, suffering from trismus, and are in mortal danger because of their inability to expectorate.

Fig. 1166.—Usual type of tracheal dilator.

In the first group the operation prevents death from impending suffocation. In the second group it enables aspiration of bronchial secretions that the patient is unable to expectorate, and spares the patient being drowned in his own secretions. To be enabled to carry out suction effectively the inner tube must be of such a diameter that it will not be occluded by the passage of a No. 3 or 4 rubber catheter: tracheostomy tubes between the sizes of 28 and 32 French catheter gauge fulfil these requirements.

When to perform tracheostomy in a child with laryngo-tracheobronchitis is often a difficult problem. The effect of antibiotics is tried first. The patient must be watched most carefully for signs of indrawing of the jugular veins, movement of the accessory muscles of respiration, and restlessness—signs that call for the operation. The use of sedation of any kind during this period of observation is forbidden expressly.

At one stage of my career it was my duty to supervise the operation of tracheostomy (usually for diphtheria) performed by the house physician in charge. This experience gave me ample opportunity of observing that tracheostomy in a small child is by no means a trivial matter. The classical operation then taught and performed left much to be desired in the matter of exposure, and only too often the operator became embarrassed by hæmorrhage. Perhaps the most constant source of trouble was to be seen in the use of the tracheal dilator. The jaws of this instrument open when the handles are approximated (*Fig.* 1166)—that is, their action is precisely opposite to that of all hinged surgical instruments in common use, notably hæmostats and scissors. In the heat of the moment this reversed principle caused much confusion, a sufficient reason for recommending that the tracheal dilator be discarded entirely.

As far as is possible, tracheostomy should be carried out as an elective procedure, although in cases of dire necessity the operation has been undertaken successfully with a penknife.

[1] The alternative measure is to pass an endotracheal tube. To keep the bronchial tree free from secretions via the tube requires more skilful attention than is the case when a catheter can be passed through a tracheostomy tube. Moreover, if an endotracheal tube is retained for more than 8 hours, ulceration of the vocal cords, and subsequent stricture, is almost certain to follow.

Except in those rare and desperately urgent cases where the operator is single-handed (see p. 840) Digby's method of performing tracheostomy should be employed. By mastering Digby's technique we have at our command a universal method—high and low tracheostomy are no longer distinct operations. Digby's operation will therefore be considered in detail.

Details of performing the Operation of Tracheostomy.—A suitably-sized tracheostomy tube is selected, and tapes are tied to the slots in the outer tube before it is sterilized. In addition, only a few hæmostats, a pair of dissecting forceps, and a scalpel are required, but a sharp hook can be included in the armamentarium, if desired.

Anæsthesia.—In young children (who form the bulk of these cases) local anæsthesia is unsatisfactory, and a little chloroform is administered. If a skilled anæsthetist is available endotracheal anæsthesia can be employed. For older children and adults local infiltration is advised, and will be found to be eminently satisfactory. Procaine (1 per cent) is injected into the skin and subcutaneous tissue of the middle line of the neck, from the lower border of the thyroid cartilage downwards to lower border of the thyroid isthmus.

Position of the Patient.—A child should be pinned in a blanket and covered by a mackintosh sheet. A well pinned blanket serves to restrain the arms. Place the patient close to the right edge of the table; this is of especial importance in the case of a little child.

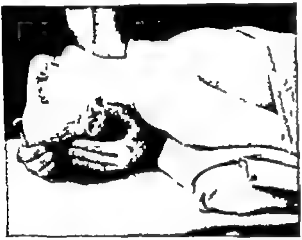

Fig. 1167.—Tracheostomy. The assistant, standing on the patient's left, places his right hand on the forehead, and his left on the occiput. He then fully extends the neck, and holds the head firmly in this position until the tracheostomy tube is safely in situ.

A small sandbag or rolled up towel is insinuated beneath the shoulders. To an assistant should be delegated the sole

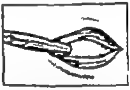

Fig. 1168.—After making a transverse incision through the fascia below the cricoid the point of a hæmostat is inserted behind the isthmus of the thyroid gland.

duty of keeping the patient in the correct position. This he does by standing on the patient's left. After fully extending the head he holds it firmly in the manner shown in *Fig.* 1167. It is of the utmost importance that the assistant should maintain this position and at the same time see that the chin and sternal notch are in the same straight line.

Once the patient is in the correct position the operator locates the cricoid cartilage and takes all his bearings from this point.

Digby's Technique.—Exactly in the middle line an incision is made from the *upper* border of the cricoid, downwards for one and a half inches. The deep fascia is divided vertically in the length of the incision between the ribbon muscles, and the cricoid is exposed. Bleeding points are clamped.

The fascia attached to the lower border of the cricoid is incised *transversely*, and the commencement of the trachea is in view. The point of a closed hæmostat is passed downwards, close to the trachea and behind the isthmus of the thyroid (*Fig.* 1168). *Slightly* opening and closing the hæmostat may assist its passage. The tissue thus raised is clamped close to the middle line by one hæmostat and then by a second placed parallel to the first. The tissue between the hæmostats is divided (*Fig.* 1169) and the hæmostats are rotated laterally through 90°, the handles being slightly depressed so as to raise the points. This rotation usually peels off the tissues sufficiently to expose the trachea, but a touch of the scalpel on each side may be necessary. The first four rings of the trachea are now exposed with the utmost clarity. In order to steady the trachea, a sharp hook can be passed beneath the lower border of the cricoid cartilage or the first ring of the trachea. In Digby's operation this step is not essential, but it is advisable in infants. A vertical incision is made through the second, third, and if necessary, fourth rings, not as a stab

but as a gentle incision with the knife held in pen-holder fashion the little finger resting upon the upper border of the manubrium. The first ring of the trachea is always to be avoided, for its division is so likely to be followed by tracheal stenosis.

As the trachea is opened the assistant should be ready with a sucker to aspirate mucus, and with a swab to prevent reflex coughing causing exudate to be ejected into the eyes

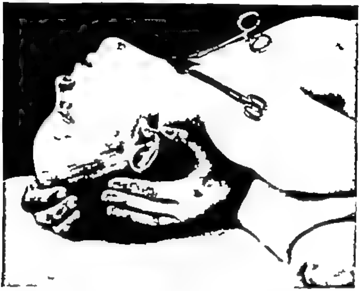

Fig. 1169 —Utilising the tunnel formed by the method illustrated in *Fig.* 1168, the isthmus of the thyroid is divided between haemostats and the trachea exposed.

of beholders. Seizing one edge of the tracheal wound with dissecting forceps, snip off small portions of the third ring with scissors, so as to form a round window in the anterior wall of the trachea (*Fig* 1170). This is much better than thrusting the tracheostomy tube through a mere slit. It at once relieves dyspnœa and allows the thyroid isthmus, already clamped, to be ligated. Following this, vessels clamped on the side of the wound are ligated

Fig 1170.—A round window is cut in the trachea, centred over the third ring

Fig 1171 —Tracheostomy completed Observe that the skin is not approximated around the tube.

also. The tracheostomy tube is inserted the pilot removed, and the tube is held firmly against the neck while the ends of the tapes, which have been passed behind the neck, are tied (*Fig* 1171). It should be noted particularly that the skin must not be approximated about the tube owing to the danger of subcutaneous, and even mediastinal emphysema. The skin incision should be left open or at the most, a single stitch put above the tube A piece of tulle gras can be split in such a manner as to pass between the wings of the

tracheostomy tube and the skin, thus covering the incision. It is only after this has been completed that the assistant releases his grasp of the patient's head.

Tranquil Tracheostomy (Sir St. Clair Thomson).—The commotion that attends the first entry of air into the trachea can be avoided by the intratracheal injection of cocaine. A hypodermic syringe is charged with 20 min. (1.2 ml.) of a 2½ per cent solution of cocaine in the case of an adult and 5 min. (0.3 ml.) of 1 per cent solution in the case of a child. As soon as the tracheal rings are laid bare the syringe is grasped as one does a pen, with the forefinger about an inch (2.5 cm.) from the extremity of the needle. The middle, ring, and little fingers rest on the neck, and they prevent the point from penetrating more than a quarter of an inch (6 mm.) within the lumen of the trachea. The cocaine solution is injected into the cavity of the windpipe and the needle is withdrawn sharply. The liquid in the trachea at once gives rise to a slight cough, but it causes no distress. If there is no great urgency as much as ten minutes should elapse for the cocaine to take its full effect. At the end of that time the incision into the trachea can be made, and the tracheostomy tube is introduced without spasm or even the slightest cough. The calm with which this procedure takes place is in striking contrast with the agitated, hurried, and often bloody and dangerous operation of former days" (Sir St. Clair Thomson).

Immediate Post-operative Care.—As a rule, as soon as the tracheostomy tube is in place, most of the anxieties of the case fade perceptibly. Should respiration fail, artificial respiration must be commenced immediately with due regard to a clear airway via the cannula. The inner tube is inserted and instructions are given that it should be removed, sterilized and reinserted as often as needed. A duplicate tracheostomy tube should always be at hand, and also oxygen and CO_2 in case the respiratory excursions become inadequate. Arrangements must be made for constant attention to the patient. Remember that a patient with a tracheostomy cannot call for help.

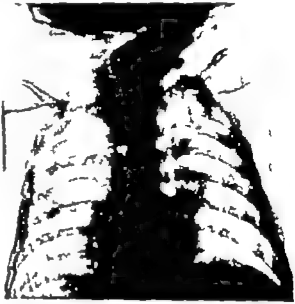

Fig. 1172.—Mediastinal emphysema following tracheostomy. (*Mr. F. Bauer's case.*)

More Remote Post-operative Care.—A special nurse is desirable for the first day or two following the operation. The room should be well ventilated, free from dust, and the temperature about 70° F. (21° C.). As soon as the patient can swallow he must be encouraged to drink large quantities of fluid, in order to render the secretion less viscid: this is far more effective than nursing the patient in a steam-tent. A sucker with a catheter attached should be at hand to keep the trachea free from exudate.

Nursing Instructions.—Beside the bed there should be a trolley containing duplicate cannulæ, retractors, a fine hæmostat for use as a tracheal dilator, a fine rubber catheter with a well fitting syringe attached, and dressings. Oxygen and CO_2 should be at hand to relieve acapnia, which sometimes occurs after the relief of laryngeal obstruction. If possible, the patient should be nursed sitting up and the inner tracheostomy tube must be removed and, as often as needed, cleansed with a pipe-cleaner before boiling. The respiration of a patient with a properly fitting tracheostomy tube, which is kept free from obstruction by secretion, is inaudible. In order to remove secretion from the trachea the nurse must be shown how to pass a rubber catheter into the tube and apply suction. A most important duty of the nurse is to wipe away secretion quickly after a patient has coughed before it is sucked in. The incision in the neck is covered by a piece of slit gauze, allowing it to fit under the wings of the tracheostomy tube as described above: this should be changed as often as necessary.

Removal of the cannula should not be attempted until the patient can sleep with the tube corked completely. First of all, half-corking is used as a method of trial.

Complication.—

Mediastinal Emphysema occurs to some degree in 40 per cent of cases. In severe examples the air in the mediastinum causes the mediastinal pleura to rupture and a pneumothorax results. The cause of the mediastinal emphysema is an abnormally low intrapleural tension—air is sucked into the tissue planes before the trachea is opened. On this account the tissues around the trachea should be disturbed as little as possible in particular the pretracheal fascia must not be lifted away from the trachea The preliminary passage of an endotracheal tube or a bronchoscope obviates this complication at the time of the operation.

Should dyspnœa and cyanosis occur *after* tracheostomy has been performed, and the airway is free one should think of the possibility of mediastinal emphysema, the diagnosis of which can be confirmed by radiography (*Fig* 1172)

Post-operatively severe mediastinal emphysema occurs if the outer tracheostomy tube is coughed out.

Apart from oxygen therapy in high concentration there is no special treatment. The extravasated air is absorbed slowly

ASPIRATION OF BRONCHIAL SECRETIONS THROUGH THE TRACHEOSTOMY TUBE

A mechanical suction apparatus is almost essential, though good work can be accomplished by aspirating with a well fitting syringe. A selection of fine Jacques rubber catheters should be in readiness, and two or three additional holes are cut near their extremities. They are sterilized by boiling and lubricated with sterile water The frequency with which suction is applied is gauged by the speed with which respirations become noisy or by auscultation of the chest. When mucus is very viscid and difficult to aspirate a detergent such as alevaire[1] administered by a fine nebulizer will make the secretion more fluid. Should extensive bronchitis or bronchopneumonia be present the resulting cyanosis can be relieved by giving oxygen via a catheter passed into the trachea through the tracheostomy tube.

Additional Measures.—The patient should be turned from side to side every hour in the early days following tracheostomy . Percussion of the chest will help to dislodge mucus from the more peripheral bronchi areas of diminished air entry will indicate where percussion should be applied.

Aspiration of bronchial secretions through a tracheostomy permits the head and chest of an unconscious patient to be raised this position serves to diminish cerebral congestion and facilitates excursion of the diaphragm which improve both pulmonary ventilation and venous return to the heart This position however must never be employed in patients with bleeding into the nasopharynx (e.g fractured base) those who are liable to vomit (gastric aspiration over rules this objection) and those who are suffering from shock.

OPENING THE WINDPIPE IN CASES OF DESPERATE URGENCY

Laryngostomy —As a temporary means of relieving sudden laryngeal obstruction *in adults* laryngostomy is unsurpassed. It is performed very easily free from danger and the wound heals readily It should not be employed in children

H H. aged 19 had a sore throat for twenty-four hours. He gargled with vinegar but went to work. At 6 p.m. he had difficulty in breathing and called in his doctor who finding the patient cyanosed, sent him to hospital. With a laryngeal mirror it was possible to see the œdematous glottis, which presented an appearance very like a normal cervix uteri. The throat was sprayed with cocaine, and he was ordered inhalations of tinct. benzoin. co., with some benefit At 3 a.m. I was summoned to find the patient cyanosed, sweating and fighting for breath. Laryngostomy was performed. Recovery

Fig 1172.—Site of the opening in laryngostomy

Technique —The patient s head is extended and held in the midline

1 *A vertical fold of skin is pinched up so that its centre is at the level* of the upper border of the cricoid cartilage when the head is extended.

2. The centre of the uplifted skin is then transfixed and cut through so as to make a transverse incision 1 in. (2 5 cm.) in length.

3. A pair of pointed scissors is plunged through the cricothyroid membrane (*Fig* 1173) downwards and backwards close to the upper border of the cricoid so as to avoid the small transverse artery

[1] Bayer Products Ltd., Neville House Eden Street Kingston upon Thames, Surrey

4 The laryngostomy tube (*Fig* 1174) is inserted between the blades of the widely opened scissors.

Fig 1174.—Butlin's laryngostomy tube with pilot. Sir Henry Butlin usually employed the largest size

Any bleeding is checked by the insertion of the tube. In cases of desperate urgency a knife held short can be *plunged through the cricothyroid membrane*. The knife is held in the opening with a slight twist until a closed safety pin, or some such object, is available.

See also LOTT THYROIDECTOMY, TRACHEOSTOMY p. 866

DESPERATELY URGENT TRACHEOSTOMY

Chevalier Jackson's Instructions.—The patient's body being supported by chairs or across the bed, his head is extended over the left knee of the seated operator. The thumb and third finger of the left hand depress the sternomastoid muscles on either side, thus protecting the great vessels and at the same time steadying the laryngeal and tracheal cartilages; remember to use the second, and not the index, finger for this purpose. With a scalpel in the right hand, a bold sweep is made exactly in the middle line from the cricoid to below the isthmus of the thyroid gland. The incision traverses skin, cervical fascia, the thyroid and the thyroid isthmus, so as to expose the trachea. *The left index finger is introduced* into the bleeding wound to identify the rings of the trachea. Using the index finger as a guide, the second, third, and *fourth* rings of the trachea are divided longitudinally (*Fig* 1175). The handle of the scalpel is then wedged into the tracheal incision and the tracheal cartilages are forced apart to admit the tracheostomy tube (*Fig* 1176). Only after satisfactory breathing has been restored is any attempt made to arrest bleeding by ligatures or, what is usually effective, by winding 1 in. (2.5 cm.) of ribbon gauze around the tube beneath its wings.

Fig. 1175.—Desperately urgent tracheostomy

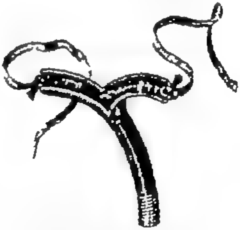

Fig 1176.—An emergency tracheostomy tube can be made of rubber tubing. Even in a hospital this may be required as a temporary expedient.

ENDOTRACHEAL INTUBATION

Another most useful *temporary* method of overcoming laryngeal obstruction is to insert a catheter, either by way of the nose or mouth, so that its eye comes to lie beyond the site of the obstruction. *Every operating theatre possesses the simple, yet essential, apparatus*; so it behoves all hospital residents to acquire some practice in the procedure during those formal operating sessions when endotracheal anaesthesia is employed.

A Magill's tube evenly lubricated with 1 per cent nupercaine in lanoline is passed—preferably through the nose—so that its tip presents in the pharynx. With the laryngoscope the vocal cords are visualized the end of the tube, grasped in forceps passed through the laryngoscope, is then insinuated between the vocal cords so as to enter the trachea.

CUT THROAT

SUPERFICIAL WOUNDS

In more than half the cases of cut throat which reach surgical aid the wound does not involve any vital structure—that is, only the skin, platysma, and perhaps the sternomastoid or other muscles are severed. Even the external jugular vein does not often come under the category of a vital structure in this respect. The treatment of this superficial variety follows elementary surgical principles. The wound edges are cleansed and trimmed, the vessels are ligatured, the muscles are stitched together with catgut, and the wound is closed, usually without drainage.

DEEP WOUNDS

Of deep wounds of the throat much more must be said. The wound, when self inflicted by the right hand, is usually deeper on the left. In about 97 per cent of cases the air-passages are opened. The thyroid vessels and internal jugular vein are frequently wounded. Bleeding into the severed larynx or trachea is a common cause of death. Unless this is realized, packing the wound, a justifiable temporary expedient in certain circumstances, may precipitate rather than delay a fatal termination.

Some General Operative Principles.—It is usually advisable to enlarge the wound so that a good view of the interior can be obtained. All bleeding vessels are secured, and there should be no hesitation in tying the internal jugular vein above and below a wound of this vessel. If there is blood in the air passages this should be sucked out. If there is no mechanical sucker available a catheter and a bladder syringe will prove valuable. Except in a dire emergency it is better not to insert a tracheostomy or laryngostomy tube through the wound, but rather to perform tracheostomy below the opening and to repair the wound in the air passage. In this way cicatricial stenosis of the larynx, a common complication when the tube is inserted through the original wound, is largely avoided. Wounds at various levels (*Fig* 1177) will now be considered in more detail.

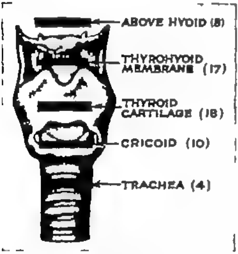

Fig 1177.—Position of the wound into the air passages. Analysis of 87 cases of suicidal cut throat with a deep wound.

Wounds above the Hyoid Bone.—After cleansing the area, explore the wound with a finger It will sometimes lead into the mouth. If this is the case, as soon as spurting vessels have been clamped (the facial artery usually requires attention) examine the epiglottis. The epiglottis is quite often partially cut through near its base; rarely it is divided completely Sew the divided epiglottis with catgut—the stitches hold fairly well. The mucous membrane of the pharynx is trimmed with scissors and united. If the submaxillary gland is badly lacerated, it is best removed. Unless the case is an early one and comparatively uncontaminated—a rare event if the pharynx has been opened—it is best to pack the superficial part of the wound with petroleum jelly gauze and apply a viscopaste bandage. If the wound merits it, delayed suture can be undertaken.

Wounds of the Thyrohyoid Membrane.—Again the wound is explored with the finger An opening through the thyrohyoid membrane is a common operative finding The epiglottis is found partially divided in nearly half the cases. In one example the top of the epiglottis was almost completely severed, and this fragment of over an inch was removed without harmful effect. As a rule an effort should be made to repair the epiglottis. If the side wall of the pharynx had been opened, it must be united carefully The severed thyrohyoid membrane then receives similar attention; the wound should be trimmed and sutured. If the wound is a small one and after it has been closed there is no respiratory

distress, it is unnecessary to make an artificial airway. In the majority of instances, however, tracheostomy is advised.

It is important to note that it is laryngostomy or tracheostomy by Digby's method that is recommended. The examination of notes of a large number of cases has shown me that the difficult and hæmorrhagic operation of low tracheostomy is often performed in this and the next variety of cut throat. If at the commencement of the operation respiratory distress is in evidence, tracheostomy should be performed before attention is directed to the wound.

Wounds of the Thyroid Cartilage.—An incised wound of the thyroid cartilage is fairly easily repaired, but stitches through cartilage tend to cut out. If only slight tension is applied, and especially if a mattress suture can be inserted (*Fig.* 1178), the thyroid cartilage is united readily. It is advisable to perform tracheostomy.

Occasionally there is loss of substance of the larynx, for instance, when a triangular piece from the front of the thyroid cartilage has been removed. By detaching one end of a pretracheal muscle, it is usually possible to swing this over and suture it into place in such a way as to patch the defect.

In rare instances the front wall of the larynx is found to be cut out. In such cases, after performing tracheostomy, if feasible the detached cartilage is sutured into position in the hope that it will remain viable. When this is impracticable, the defect is covered by skin. Usually the vocal cords are implicated, and perhaps fortunately such cases usually succumb.

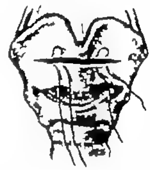

Fig. 1178.—Suturing the thyroid cartilage.

Wounds immediately above or below, or through the Cricoid Cartilage.—Tracheostomy should be performed. The edges of the wound are then trimmed, the larynx is closed with interrupted sutures, and after débridement, the superficial tissues are united with drainage.

Wounds of the Trachea.—It is important to get good exposure. Divide the thyroid isthmus between clamps. Should the wound be low in the trachea, which is unusual, a tracheostomy tube can be placed through the trimmed opening in the trachea, but in order to prevent possible stenosis, usually this is better avoided. In most instances it is advisable to perform tracheostomy below the wound and then proceed to repair the latter with sutures.

Wounds of the Normal Thyroid Gland are readily united with deep sutures, a procedure which soon quells the somewhat alarming hæmorrhage.

Complications after Cut Throat.—*Bronchopneumonia* is a common complication, and is more frequent after the pharynx has been wounded; consequently antibiotic treatment is given in all cases.

Suppuration is, of course, prone to follow any incised wound caused by a non-sterile implement; nevertheless, thanks to the excellent blood-supply, suppuration is not much in evidence, unless the pharynx has been opened. In such cases only the mucous membrane of the pharynx should be sutured, the remainder of the wound being left open.

Œsophageal fistula followed in one case of which I have notes. It healed slowly.

Stenosis of the larynx and necrosis of cartilage is favoured by inserting the tracheostomy (or laryngostomy) tube through the original wound in the air-passage.

A question which crosses our mind is whether suicidal cut throat is a condition upon which it is worth while expending much trouble. It is not the surgeon's province to adjudicate; it is his duty to do his best to repair the damage. Sometimes with the healing of the wound the patient is thankful. For instance, a patient aged 58 with prolapsed hæmorrhoids was noticed to speak in a whisper and bore a transverse irregular scar on his neck. On laryngoscopy only his right vocal cord could be seen. It transpired that at the age of 18 he had been jilted. In this case surgical effort had been rewarded, for he had lived a most useful life serving as a surgical instrument manufacturer.

CERVICAL SPINAL SHOCK ('WHIP LASH') INJURY OF THE NECK

In 90 per cent of cases this accident, which has become relatively common, is due to a motor-car accident in which usually one car bumps into the back of a car ahead. The forward snap of the head on the body causes severe trauma to the neck. Initial loss of

consciousness is not at all uncommon. Sometimes a fracture of the spinous process of the 6th or 7th cervical vertebra is present. In a very small proportion of cases a ruptured cervical disk requiring operation results. In most cases the main injury is ligamentous and muscular. When consciousness, if lost, is regained the patient is best treated by cervical extension (*see* p. 703) for about a week. If radiographs are negative, physiotherapy is then commenced and continued until the patient is symptom free. With legal action for compensation pending, the incidence of traumatic neurasthenia is very high.

FRACTURED HYOID BONE

This rare happening, usually the result of attempted strangling, has been accompanied by a high mortality, owing to œdema of the glottis becoming complete suddenly and unexpectedly. For this reason the wise course is to perform tracheostomy in every case. This forestalls the complication and affords some degree of rest to the fractured bone.

The same injunctions hold good for the even more rare accident of fractured thyroid cartilages.

SUPRAHYOID INFECTIONS OF THE NECK

Ludwig's angina, infection of the masticator space, and infection of the pharyngomaxillary space have the following features in common. Each occurs above the level of the hyoid bone; each is an infection of a closed fascial space, and as such is a menace to life. Except in very early cases where, of necessity, the diagnosis is uncertain, reliance cannot be placed on antibiotic therapy alone—the infected space must be drained.

LUDWIG'S ANGINA

In 1836 Wilhelm von Ludwig described a clinical entity characterized by a brawny swelling of the submandibular region combined with inflammatory œdema of the mouth. It is the *combined* cervical and intrabuccal signs that constitute the characteristic feature of the condition (*Fig.* 1179). It may begin in either situation, but until it spreads from the submandibular tissues to the sublingual tissues, or in the reverse direction from the sublingual tissues to the submandibular region, it does not constitute Ludwig's angina.

Fig. 1179.—Ludwig's angina. The swelling in the submental region, and the inability to close the mouth owing to œdema of the tongue and floor of the mouth, can be seen.

The essential pathology of the condition is an infection of the closed fascial space about the submandibular salivary gland.

Course of the Disease.—Unless tension is relieved certain cases rapidly assume a grave aspect. The swollen tongue is pushed towards the palate and forwards through the open mouth, while the cervical cellulitis extends down the neck in that most dangerous plane—deep to the deep fascia. Only too often, in 12–24 hours the patient's life is threatened or taken. At necropsy upon a man of 42 who died of Ludwig's angina soon after admission to the Liverpool Royal Infirmary, H. A. Bickersteth found "nothing abnormal superficial to the deep cervical fascia, but beneath that structure a diffuse cellulitis. All muscular interstices and the connective tissue surrounding the trachea were infiltrated with seropurulent fluid extending upwards to the root of the tongue and downwards to the anterior mediastinum." Cultures show that in about 70 per cent of cases the infecting organism is a streptococcus.

Peculiar Dangers of Ludwig's Angina.—Here we are confronted with infection of a fascial space walled in on all sides by dense fasciæ and muscles, a space where clinical experience and experimental injection demonstrate that inflammatory exudate can, and does, pass via the tunnel occupied by the stylohyoid to the submucosa of the glottis. It is imperative to release tension in any closed fascial space, but in Ludwig's angina the

call for action is doubly urgent, for in addition to the dangers of impending septicaemia there is the threat of suffocation from oedema of the glottis.

Early cases of Ludwig's angina may respond to penicillin therapy in doses of 1,000 000 units at 12 hourly intervals. Nevertheless, when the signs simulate those depicted in *Fig* 1170 it is unsafe to risk sudden respiratory obstruction and other complications when an operation, performed correctly removes this danger and is followed by rapid convalescence

There is only one certain method of decompressing this closed fascial space and that is by dividing the mylohyoid.

Anaesthesia.—Before commencing see that tracheostomy instruments and an endotracheal tube are at hand. Inhalation anaesthesia of any kind should be avoided for it is unnecessary and often dangerous. Nitrous oxide gas is particularly dangerous. Intravenous anaesthesia is also contra indicated; a number of fatalities have occurred from its use in this condition. In fully fledged cases of Ludgwig's angina the only safe anaesthetic to employ is a local anaesthetic. I have found regional block analgesia most satisfactory No morphine should be given, as this depresses the respiratory centre if time permits (and it usually does) a suitable dose of pethidine is administered, and the eyes are blindfolded securely

Fig 1180 —Inducing regional cervical block analgesia.

The head is turned to the left so as to render the right sternomastoid muscle tense The middle of the posterior border of the muscle is sought, and a point just below the crossing of it by the external jugular vein is chosen. A finger breadth below this point a weal is raised in the skin. A fine lumbar puncture needle is inserted to a depth of half an inch (12 mm.). Its point is then directed upwards towards the base of the skull and the shaft of the needle is passed at the depth of half an inch (12 mm.) to its full extent (*Fig* 1180). A 20-ml. (6 dr) syringe loaded with 15 ml. (4 dr) of a 1 per cent solution of procaine is attached

Fig 1181.—Miss B. M., aged 22. A most fulminating case of Ludwig's angina. The patient was dyspnoeic and slightly cyanotic at the time of the operation. Regional block analgesia employed. Photographs on the fourteenth day after operation. A linear scar resulted without secondary suture

to the needle After aspirating to ensure that a blood vessel has not been entered the analgesic is injected slowly and evenly as the needle is withdrawn The same procedure is carried out on the left side Within a minute the analgesic should have taken effect When the patient still feel a needle-prick in the skin of the involved area as did Miss B M (*Fig* 1181), a little procaine solution can be infiltrated into the subcutaneous tissues along

the proposed line of incision observing that the pus lies deep and not in the subcutaneous tissues this practice has much to commend it, for it gives the operator confidence to proceed boldly

Operation.—The incision is shown in *Figs.* 1182 and 1183. It is recommended to extend the incision over the middle line. The incision is deepened, the platysma being divided. The lower flap is retracted strongly the submandibular salivary gland is in view

Fig 1182.—Incision for Ludwig's angina.

Fig 1183.—Patient recovering from Ludwig's angina. Showing large incision under the mandible

By blunt dissection between the lower margin of the jaw and the submandibular gland, the facial artery (*Fig* 1184) is identified and divided between ligatures. When this has been accomplished the submandibular salivary gland can be loosened from its bed with the finger and retracted downwards. The mylohyoid muscle is now accessible and it is divided freely Often pus will be found beneath the mylohyoid muscle around the buccal prolongation of

Fig. 1184 —The parts involved in the operation for Ludwig's angina. The position of the incision is shown. The submandibular gland is retracted downwards. The facial artery is divided between ligatures. The mylohyoid is now exposed and divided.

the submandibular gland. The wound is left completely unsutured (*see Fig* 1183) and packed lightly with petroleum jelly gauze. Antibiotic therapy is continued. Excision of the submandibular salivary gland is not recommended unless the surgeon is familiar with this operation and has performed it several times with local infiltration.

Ludwig's angina is a *clinical* entity. This being so it is customary and correct to confine the use of the term to those cases of virulent cervical cellulitis commencing in the submaxillary triangle. Ludwig's angina seldom if ever spreads down the neck, probably because its effects are lethal before the purulent exudate can escape from its strict confines.

INFECTION OF THE MASTICATOR SPACE

Dento-areolar and subperiosteal infection of the mandible sometimes extends to involve the masticator space which is a closed fascial space occupied by the ascending ramus of the mandible, and bounded externally by the masseter muscle, internally by the pterygoid muscles, and superiorly by the temporal muscle. An infection of this space has become a clinical entity since it was described first by Coller and Yglesias in 1934. On coronal section the masticator space appears as a fascio-muscular sling containing the muscles of mastication and the ascending ramus of the mandible. As shown in *Fig.* 1185 the masticator space is usually implicated by posterior extension of infection from a molar tooth, especially the third molar. This space lies immediately lateral to the pharyngo-maxillary space, and consequently signs of its involvement resemble closely those of infection of the pharyngo-maxillary space. Early pronounced trismus is, however, a leading sign of infection of the masticator space: as soon as either the masseter or the internal pterygoid muscles become involved in the infection, trismus occurs. A recent history of peridental disease of a molar tooth is extremely helpful. The predominance of internal or external induration and swelling depends upon which aspect of the mandible is involved.

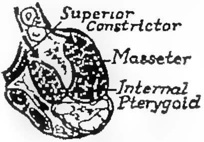

Fig. 1185.—The masticator space with arrows indicating the course of dento-alveolar infection. (*After C. Hall.*)

Mrs. V. B., aged 28, developed an alveolar abscess. The left lower molar tooth was extracted, but this did not relieve the pain and the swelling of the face increased. The temperature rose to 103° F. (39·4 C.) and repeated rigors occasioned grave anxiety, the more so because chemotherapy had no apparent influence on the course of the infection. So passed another 48 hours, the temperature rising on occasions to 104° F. (40° C.). On the fourth day she was conveyed by ambulance to London, a matter of some thirty miles. She was slightly cyanotic; the left eye was closed by œdema, and there was much swelling of the left side of the face. The most untoward sign was a brawny swelling of the submandibular region which extended over the middle line, and this, the attending doctor said, had visibly advanced in four hours. Absolute trismus was present. The patient intimated that she had difficulty in breathing, and felt as if she was choking. To drain the abscess, if such was present, seemed imperative. A general anæsthetic was out of the question. Intravenous anæsthesia would be most dangerous, because of the œdema of the glottis and the trismus.

Fig. 1186.—Forty-eight hours earlier the incision described in the text was made without anæsthesia. At the time of the operation asphyxia was threatened.

Morphine, $\frac{1}{4}$ gr. (16 mg.) and hyoscine $\frac{1}{150}$ gr. (0·43 mg.) were given subcutaneously and twenty minutes later the patient was taken to the operating theatre. Without anæsthesia a vertical incision was made a finger breadth in front of the lobule of the ear which appeared to correspond with the maximum amount of induration, as opposed to œdema. I plunged the knife right down to the bone, and was dismayed that no pus was forthcoming. A hæmostat was introduced, and still no pus. The little finger was introduced, and at the bottom of the wound bare bone was felt; a closed hæmostat was insinuated around the posterior border of the mandible and a large gush of stinking pus flowed under considerable pressure. A corrugated rubber drain was inserted. Penicillin was administered. Improvement set in almost immediately (*Fig.* 1186). A dental surgeon removed two infected teeth a week later. A sequestrum was extruded into the mouth at the end of three weeks, after which the external wound healed.

INFECTION OF THE PHARYNGO-MAXILLARY SPACE

The pharyngo-maxillary space first described by H P Mosher in 1920 is a potential cone-shaped space base uppermost. The base is formed by the base of the skull; the apex abuts the great cornu of the hyoid bone (*Fig* 1187) The medial wall consists of the superior constrictor muscle the lateral wall, from above downwards, is composed of the fascia covering the internal pterygoid muscle the mandible about its angle and the submaxillary salivary gland, below which the apex of the space becomes relatively superficial

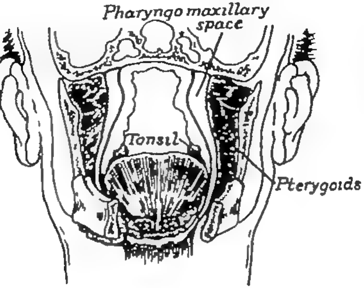

Fig 1187 —Coronal section showing the relations of the pharyngo-maxillary space

The posterior boundary of the space is the prevertebral fascia Within the space lies the carotid sheath.

When infection from the tonsil or pharynx (including the adenoid region) extends laterally through the superior constrictor muscle it enters the pharyngo-maxillary space. In a number of instances infection has occurred after tonsillectomy particularly when performed under local anæsthesia.

Diagnosis.—The elevation of temperature and the general reaction is greater than that accompanying a peritonsillar abscess every peritonsillar abscess is a potential pharyngo-maxillary space infection. There is pain on swallowing The tonsil, if present, and the lateral pharyngeal wall are pushed towards the middle line Pressure of the pus within the space laterally against the internal pterygoid muscle causes a certain degree of trismus, which is seldom as pronounced as that accompanying infection of the masticator space. External swelling over the lower and inferior area occupied by the parotid gland is usual this is never present in quinsy Should the inflammation reach the inferior limit of the space at the level of the hyoid bone induration, swelling, and tenderness below the angle of the mandible will result. The intimate relationship of the pharyngo-maxillary space to the contents of the carotid sheath make thrombophlebitis of the internal jugular vein a common complication, while dreaded erosion of an artery usually the internal carotid artery is wont to occur if the infected space is left undecompressed for any length of time. Repeated rigors are evidence of thrombophlebitis of the internal jugular vein, and are an indication that no time must be lost in ligating that vessel. Sudden discharge of a large quantity of pus through the external auditory canal usually signifies rupture of a pharyngo-maxillary abscess between the cartilaginous plates of the external auditory canal without involving the middle ear The jugular chain of lymphatic nodes may be inflamed simultaneously but in most instances this is not a prominent feature

Treatment.—It is probable that early antibiotic therapy aborts the infection, but, like Ludwig's angina, once the diagnosis is manifest drainage of the space is imperative An incision is made a finger's breadth below and behind the angle of the mandible on a line

towards the hyoid bone (*Fig* 1188) After the superficial structures have been separated a finger is inserted into the space between the submandibular and parotid glands, medial to the mandible and upwards along the inner aspect of the internal pterygoid muscle, into the pharyngo-maxillary space. The space is drained with a large Penrose drain If thrombophlebitis of the internal jugular vein is suspected, an incision 3 in. (7 5 cm.) in length is made along the anterior border of the sternomastoid muscle so that, in addition to drainage of the space, adequate exposure of the internal jugular vein can be secured to permit treatment of this complication.

Complications.—

Thrombophlebitis of the Internal Jugular Vein.—There are no characteristic local symptoms and signs of phlebothrombosis of the internal jugular vein. The signs are those of septicæmia, although torticollis to the opposite side is indicative of this complication. Rigors do not occur in children with thrombophlebitis of the internal jugular vein as often as is the case in adults, but profuse sweating occurs at all ages and if not remedied by a correspondingly high fluid intake (parenteral administration is necessary) dehydration results. If the condition is not treated by (1) drainage of the space (2) ligation of the internal jugular vein, and (3) massive antibiotic therapy meta static abscesses soon develop and a fatal issue is imminent. In doubtful cases it is a good practice to resect a small segment of the vein so that it can be submitted to microscopical examination.

Fig 1188.—Incision fo draining the pharyngo-maxillary space

C F Lake's Case —

Two days after tonsillectomy a man aged 26 felt ill, and commenced to have rigors. A swelling appeared on the right side of his neck. The right tonsillar fossa was swollen. It was decided to try the effects of antibiotic therapy and blood transfusion. Forty-eight hours later there was no improvement, and the swelling was more pronounced. An oblique incision was made on the right side of the neck, following the anterior border of the sternomastoid. The pharyngo-maxillary space was drained and the internal jugular vein was found to be thrombosed. The vein was opened, and contained frank pus no bleeding from it occurred. On the second post-operative day the temperature rose to 106° F (41 1 C.) and continued thus elevated until the patient died.

In a second case with an almost similar history Lake drained a pharyngo-maxillary abscess without waiting to see the effects of antibiotic therapy The patient recovered.

Erosion of an Artery —There is usually warning in the shape of a small leak of blood into the pharynx. At other times the initial bleeding occurs from the external auditory canal. Sometimes successive layers of clot occur giving rise to a pseudo-aneurysm which constitutes a mass that causes bulging of the lateral pharyngeal wall—on no account must such a swelling be incised. These initial bleedings are the forerunners of a catastrophic hæmorrhage which will exsanguinate the patient in a few minutes. No matter how small the first hæmorrhage, it calls for immediate placing of a ligature around the common carotid artery for the hæmorrhage nearly always occurs from the *internal* carotid artery The ligature can then be tied if the occasion demands. The space must be drained from without never on any account, should it be drained through the pharyngeal wall. The occurrence of massive pharyngeal hæmorrhage in deep infections of the neck is one of the most disastrous complications in all surgical practice. Of 237 patients with an abscess of the pharyngo-maxillary space, 76 died from erosion of a branch of the carotid artery—nearly always the internal carotid artery

CELLULITIS OF THE NECK COMMENCING BELOW THE LEVEL OF THE HYOID BONE

Cellulitis of any part of the neck, if it remains superficial to the deep fascia, behaves similarly to cellulitis in other parts of the body (see p. 110). It is most exceptional for deep cellulitis of the neck commencing above the level of the hyoid bone to spread below

that structure—the only notable exceptions are infection of the pharyngo-maxillary space which in point of fact spreads to the hyoid bone but seldom much below that structure and neglected cases of von Bezold's mastoiditis. It is to deep (brawny) cellulitis situated in the lower two-thirds of the neck to which attention is now directed.

When the cellulitis follows an infected lesion of the overlying skin or (on very rare occasions) acute osteomyelitis of the cervical spine *Staph. aureus* is the organism usually responsible while aerobic or anaerobic streptococci are the main infecting organisms in cases where the portal of entry was the nasopharynx, in which event by the time the cellulitis of the neck has become manifest, signs of the original infection have disappeared.

The most dangerous form of cellulitis of the lower portion of the neck is that arising from rupture of the œsophagus, or perforation of the pharynx or cervical œsophagus (see p. 830). In these cases usually crepitus is present, or gas in the tissues can be demonstrated radiologically.

Treatment.—When cellulitis commences in the lower two-thirds of the neck (excluding that arising from perforation of the pharynx or œsophagus where early operation is imperative (see p. 860)) the treatment has been revolutionized by early antibiotic therapy. Operation is no longer required urgently. Indeed, it is necessary only when fluctuation can be detected. *Otherwise reliance is placed upon antibiotics. Penicillin is given in doses* of 1 000 000 units 12 hourly. If aureomycin or terramycin is employed, either is administered intravenously in doses of 1 G. until the condition of the patient warrants oral administration. The therapy must be continued for several days after the temperature has fallen to normal. Other measures include strict confinement to bed, analgesics for pain and a nutritious liquid diet (supplemented if necessary by parenteral fluid). When an abscess requires drainage, endotracheal anæsthesia is advisable. A transverse incision is made over the fluctuating area, the deep fascia is incised, and the cavity is explored with the little finger. If necessary a counter incision is made. In cases originating in osteomyelitis of the spine a posterior incision or counter incision is essential. In all cases the cavity is drained with corrugated rubber for three days.

UNCOMPLICATED CERVICAL ABSCESS

(Suppurating Cervical Lymph nodes)

In dealing with this common condition one can delay operation with safety and advantage until the centre of the swelling is soft, or until the overlying subcutaneous tissue becomes œdematous and reddened (*Fig.* 1189). A comparatively small incision is made

Fig. 1189.—Suppurating supraclavicular adenitis secondary to a boil over the pomum Adami. Abscess drained by Hilton's method.

Fig. 1190.—Aspirating a tuberculous collar-stud abscess by the oblique method of Calot.

and a blunt-nosed hæmostat is inserted gently with due regard to the great vessels; its jaws are opened cautiously to enlarge the opening. Tube drainage is employed.

Conditions which simulate Cervical Abscess.—Inflammation may complicate a *branchial cyst*. Such inflammation almost always subsides with expectant treatment after which the cyst should be enucleated. The diagnosis of branchial cyst may be confirmed

by aspirating a little of the contents of the cyst. The substance withdrawn looks like pus, but if a drop is examined under the microscope an abundance of cholesterol crystals will be seen.

Inflammation also complicates *cystic hygroma* which is usually found in the lower third of the neck and nearly always in childhood. The diagnosis can be clinched by the translucency of the swelling. Inflammation of a cystic hygroma subsides regularly with expectant treatment.

Tuberculous Cervical 'Collar-stud' Abscess.—A tuberculous collar-stud abscess sometimes requires aspiration as a quasi-emergency measure. By timely aspiration skin involvement, fistula formation, and secondary infection can be prevented. Such abscesses should always be aspirated by the oblique method of Calot (*Fig.* 1190). A small quantity of local analgesic is injected into healthy skin about 1½ in. (3·8 cm.) from the periphery of the swelling. A wide-bore needle is introduced first subcutaneously and then deeply into the abscess cavity. After aspiration has been performed the puncture is sealed with collodion.

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CHAPTER LXXII

THE NECK (*continued*)

THE URGENT SURGERY OF THE VESSELS OF THE NECK

There is no gainsaying that many lives have been lost because a surgeon, surprised by a sudden gush of blood, has attempted to apply hæmostats blindly at the bottom of a small incision.

VENOUS HÆMORRHAGE

Under general anæsthesia, particularly when the airway is not entirely free, intravenous pressure rises: diminutive veins wax proud, main tributaries become formidable vessels, the internal jugular vein and veins of kindred girth billow into mighty bags of blood[1] that collapse suddenly in inspiration, almost at once to rise again and wellnigh burst *should the patient cough. Such a display is an eye-opener to the surgical initiate.* It should inculcate in him a resolve that his index finger will reflexly enter the wound to bung a breach. Such action, performed at lightning speed, alone can regularly stem the hæmorrhagic deluge and guard against the very real danger of air embolism. To call for a roll of gauze and to use it to pack the wound firmly is the next step.

Firm packing with gauze controls venous hæmorrhage in any situation; I cannot recall that it has ever failed me. In the first instance such packing is purely a temporary expedient. It gives one time to think and to organize, to get further packing material right to hand, to inaugurate the assembling of apparatus and materials for infusion or transfusion, and to sterilize any special instruments, such as a Gigli's saw, that may be required. It also allows time for the anæsthetist to ascertain and report on the patient's general condition.

Having assembled the necessary data, having controlled one's inward apprehension, and having calmed any agitation amongst the assistants (this often takes the form of wanting to do too much), the packing is removed steadily. During the twinkling of an eye that intervenes between the removal of the old pack and the insertion of the new, an assessment can be made as to whether the bleeding is less or *in statu quo*. How to proceed from this point onwards will depend on several circumstances, notably the probable site of the wound in the vein, the experience of the operator and the conditions under which he is working, as well as the general condition of the patient.

No contingency in the surgery of the vascular system calls for greater self-control and expeditious surgical action than hæmorrhage from the extreme root of the neck, i.e., from beneath the shadow of the clavicle. On several occasions firm packing has served me well not only as a temporary measure, but as the final method of dealing with the situation. As is shown by the following examples, amazing as it may seem, the removal of the plug is uneventful:—

Mrs. A. B., aged 35, had a discharging sinus and a mass of tuberculous lymph-nodes in the right supraclavicular fossa. The difficult dissection proceeded uneventfully to almost completion, when torrential venous hæmorrhage occurred from beneath the clavicle. Digital pressure was applied immediately and a triangular wound, large enough to be felt, was present at the junction of the internal jugular and subclavian veins. The wound was packed with dry gauze. After waiting about five minutes, and having been informed that the pulse at the wrist was satisfactory (which was proof positive that the subclavian artery was not obliterated by the pressure of the gauze) flexible adhesive plaster was carried over the shoulder in such a way as to exert steady pressure on the dressing. One week later, under general anæsthesia, the packing was removed cautiously, and it was found that the whole of the large cavity was filled with healthy granulation tissue. The wound was packed with petroleum-jelly gauze. On removing this packing at the end of a further week the cavity was found to be about half the size (*Fig.* 1101).

Mrs. C., aged 82, had had what was believed to be a dermoid cyst excised from Burns' space about two years previously. Recently the swelling had recurred. There was an obvious abscess with reddening of the skin overlying the suprasternal notch. The abscess having been incised, I

[1] If blood is issuing from a small wound of the internal jugular vein, in no circumstance should a lateral ligature be applied. It will merely 'blow off' and result in a larger wound.

was wiping out the abscess cavity in order to ascertain the source of the suppuration when terrific venous hemorrhage that must have come from the innominate vein, ensued The same measures as described in the above case were employed with the same pleasing result

Every general surgeon should be well versed in temporary resection of the clavicle and should the pulse at the wrist be obliterated by the packing of the root of the neck, this is an occasion to employ it.

Exposure of the Junction of the Carotid Jugular and Subclavian Vessels.—Sencert s method of exposing the first and second parts of the subclavian vessels is undoubtedly the key to the situation.

The incision is shown in *Fig* 1102 A. As a first step the horizontal limb of the incision alone is made This passes right down to the bone The periosteum is cleared from the clavicle in its middle and outer parts. The clavicle is divided as far laterally as circumferential periosteal clearance will allow Division is best effected with a Gigli's saw but in the absence of this instrument a chisel and mallet (with a retractor hooked under the bone to protect underlying structures) must be used The clavicular head of the sternomastoid is cut from the bone and the sternoclavicular joint opened. The interosseous ligaments of the joints are so severed as to leave the fibrocartilage attached to the sternal surface of the joint. The skin incision is now continued downwards laterally The pectoralis major is divided, after which the pectoralis minor is severed close to its thoracic origin With the assistant keeping pressure upon the packing the flap is gently elevated. The costoclavicular ligament which runs between the clavicle and the first costal cartilage must be divided, especial care being taken not to injure the subclavian vein, which lies in close proximity to this ligament. If the flap is swung outwards carefully and not with a sudden jerk no damage will be done and the great vessels of the neck are displayed magnificently (*Fig* 1192 B)

Fig 1191 —Mrs. A B fourteen days after packing the wound for torrential venous hæmorrhage from beneath the clavicle

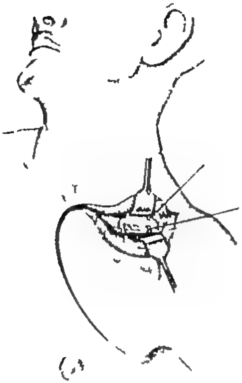
Classical incisions for exposure of arteries and veins are merely anatomical exercises they have but little application in practical surgery As far as the neck is concerned classical incisions are a menace. Incisions that give adequate exposure will be described in this book

A Good General-purpose Incision for displaying the Greater Part of the Internal Jugular Vein and the Carotid Tree.—A long oblique incision (*Fig* 1103) is made The sternomastoid muscle is divided completely This is a thick bellied bipartite muscle and it may be thought that it has been bisected when only the sternal moiety has been severed. The packing is kept firmly in place by the assistant until the sternomastoid has been severed completely Once the muscle has been divided considerable access to the interior of the neck is afforded.

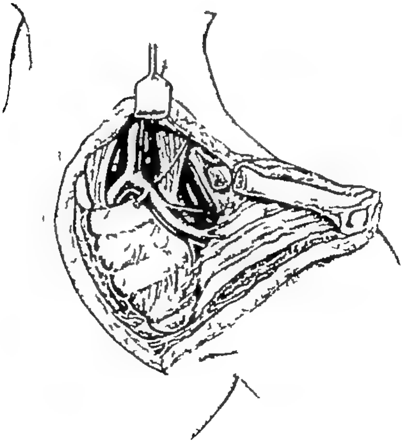
The assistant should have been instructed previously to pay particular attention to, and be ready to pinch between finger and thumb the common carotid artery and the jugular vein in the upper aspect of the wound, while by agreement the surgeon will do likewise in the lower part of the wound (or vice versa, in the case of the left side of the neck). Adopting this plan, each will then have his right hand free the assistant s for necessary swabbing and the surgeon s for accurate application of a hemostat What is to be avoided is haphazard, blind application of hæmostats, that so often proves damaging and disastrous.

An Alternative Incision to meet Special Circumstances.—When it is obvious that it is the extreme upper end of the jugular-carotid trunks that need displaying the following method will prove satisfactory —

Exposure of the Internal and External Carotid Arteries together with the Internal Jugular Vein.— An incision along the anterior border of the sternomastoid is prolonged over the



A



B

Fig 1102.—A, B Sencert method, showing the marvellous accessibility t the vessels concerned.

mastoid process (*Fig* 1194 inset) Clear the tip of the mastoid process and observe the origin of the sternomastoid muscle With a chisel and mallet, remove the distal third of the mastoid process. The tip of the mastoid having been removed, turn it back, with all the muscle inserted into it (*Fig* 1194). Under the sternomastoid will be found the posterior belly of the digastric muscle. This is isolated completely hooked up on the finger and divided straight across about its middle The divided ends of the muscle belly are turned

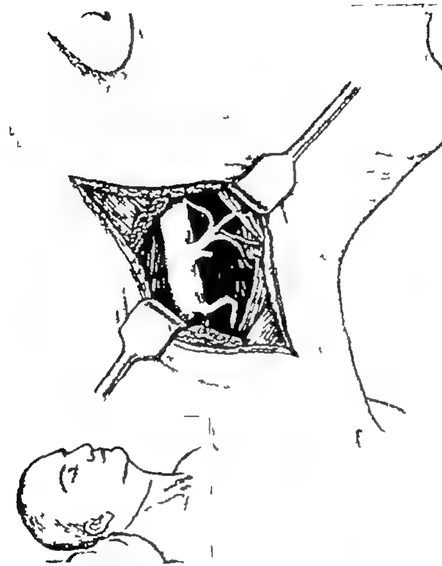


Fig. 1193.—A standard incision for exposing the carotid artery near its bifurcation and the greater part of the jugular vein.

respectively upwards and downwards. The internal carotid artery the *external carotid* artery and its branches, and the internal jugular vein right up to the bulb are displayed beautifully

Reconstruction —The divided digastric muscle is sutured Then the tip of the mastoid is fixed in place by a few sutures in order to unite the periosteum and fibrous tissue. According to the circumstances the integument will be closed completely or provision made for drainage.

Ligation of the External Carotid Artery for Hemorrhage from one of its Branches.—In order to ligate the external carotid artery *for some condition other than a wound of* the neck—for instance hemorrhage occurring from the tongue—it is *unnecessary* to divide the sternomastoid unless one is hampered for room, as is the case when the patient has a short, fat neck. *Another indication for extending the* exposure would be if enlarged lymph-nodes were found obscuring the view Under ordinary conditions an ample incision

along the anterior border of the sternomastoid with suitable retraction enables the carotid artery to be located by its pulsations. The carotid sheath is exposed and incised over the jugular vein which is freed from its fascial covering for a length of from two to three inches into the neighbourhood corresponding to the region of the bifurcation. The vein is now carefully separated from underlying structures, including the vagus nerve. The jugular vein is then retracted medially (*Fig* 1195)—not laterally as in the classical operation—until the bifurcation of the common carotid comes into view (Norman Patterson). The hypoglossal nerve tends to be retracted forwards with the vein and may not be seen of course, care must be taken to avoid damaging this nerve, or its branch the descendens hypoglossi The carotid is followed up to its bifurcation. It is essential to remember the peculiar anatomy of the region, viz., that the external carotid lies at first on the

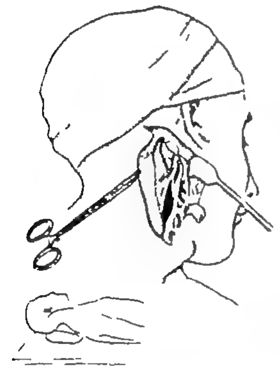


Fig 1194 —Complete exposure of the carotid arteries and the internal jugular vein. (*After Piolle and Delmas*)

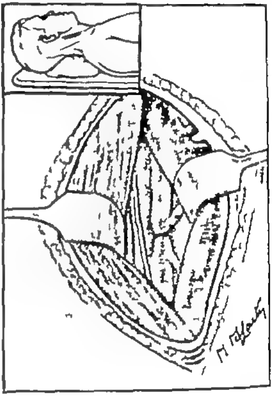


Fig 1195 —Ligation of the external carotid artery Note the jugular vein retracted medially

inner side, then in front, and then on the outer side of the internal carotid Using a Watson Cheyne's dissector the fascia is freed around the junction. That it is the external carotid artery is at once apparent at this stage, for arterial branches spring from the trunk, and this trunk only Keeping very close to the artery the better to avoid the superior laryngeal nerve, an empty blunt aneurysm needle is passed around the vessel from without inwards. A strong ligature is applied.

Exposure of the Common Carotid Artery.—A pillow is placed under the shoulders and the head is turned strongly to the opposite side. The incision is shown in *Fig* 1190 inset. It follows the anterior border of the sternomastoid to the manubrium, then outwards along the upper border of the clavicle to its middle. When the middle of the clavicle is reached the external jugular is seen It is not necessary to touch this vessel. The platysma and fascia are divided. It is convenient to cut down on to the anterior edge of the sternomastoid in the ascending limb of the incision. Having turned back the skin-flap, insinuate the finger beneath the tendinous sternal head of the sternomastoid and divide it an inch (2 5 cm) above the clavicle. Proceed in the same way to deal with the clavicular head. The sternomastoid can now be retracted in the same manner as the skin-flap (*Fig* 1190). The omohyoid will be seen crossing the underlying space. It is not necessary to divide the muscle because it can be readily drawn upwards or downwards as desired.

Under the omohyoid covered by fascia will lie the great vessels of the neck clearly exposed to view The common carotid its bifurcation and the internal and the external carotids will be seen covered partially by the veins which drain into the internal jugular The common carotid artery can now be tied if necessary

Reconstruction —The sternal and clavicular heads are sutured to their respective stumps. The stitches should be of the mattress type and include the superficial fascia.

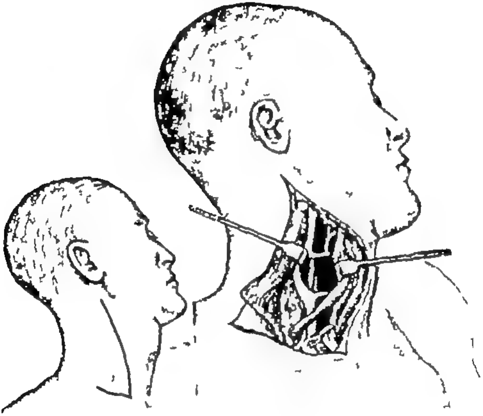


Fig 1196.—Exposure of the common carotid art ry (*After Piolle and Delmas*)

Should drainage be necessary a piece of corrugated rubber is inserted at the lower edge of the wound. The skin incision is closed.

Observations on Ligation of the Carotid Arteries.—

"*The possible occurrence of cerebral complications has invested ligature of the common carotid artery with a gravity associated with but few operations.*" (R. Matas.)

The *external* carotid artery can be ligated with impunity In the case of the *common carotid artery* and especially the *internal carotid artery* matters are entirely different. It is true that when the patient is young and not enfeebled by shock and hæmorrhage the chances of the circle of Willis being adequately served by a unilateral arterial supply are reasonably good. Nevertheless, on all occasions suddenly cutting off the blood flow through the internal carotid artery or common carotid artery should be avoided if possible

The common carotid artery should not be tied in continuity but divided between ligatures, the better to avoid emboli being carried to the circle of Willis following their displacement by the pulsation of the arterial segment below the ligature (Lambert Rogers)

The Urgent Surgery of the Jugular Vein.—

Wounds —A wound of the internal jugular vein situated between the level of the tip of the mastoid process and the upper border of the clavicle can be dealt with through an incision along the anterior border of the sternomastoid, with division of the sternomastoid if exposure is too meagre After temporary control of the hæmorrhage by packing, the wound is extended if necessary *The vein is ligated* a reasonable distance above and below and the damaged section resected. I have ligated the internal jugular vein so many times and

at all periods of life from tender years to old age that it can be stated with assurance that the procedure is not followed by any untoward effect.

Hæmorrhage from the Internal Jugular Vein at its Exit from the Skull.—It has been indicated that detachment of the mastoid process gives good exposure of the internal jugular vein almost to the base of the skull. I left a long hæmostat on a lateral wound of the bulb of the jugular vein for forty-eight hours, and, after loosening the ratchet, the hæmostat was removed one hour afterwards uneventfully. I know of a case where firm packing was employed and left in place for six days. This also was successful.

Ligation.—Apart from wounding of the vein, ligation of the internal jugular vein is undertaken to prevent spread of infection from an infected lateral sinus. The internal jugular vein can be ligated through a comparatively small transverse incision opposite the middle of the anterior border of the sternomastoid. As soon as this muscle is displayed it is retracted backwards. There is seldom any difficulty in locating the large venous trunk. If there is, the wound must be extended somewhat. Difficulty in finding the vessel usually means that it is thrombosed.

Should the vein be distended, but filling and emptying do not occur, that it is a bag of pus can be confirmed by aspiration. In this rare event ligation above and below incision, sucking out of the pus, drainage and antibiotic therapy are the procedures indicated.

LIGATURE OF THE LINGUAL ARTERY

In urgent surgery ligation of the lingual artery is rarely indicated. On one occasion ligature of both lingual arteries, which under the circumstances was the only procedure possible, served me well:—

I was called to see H. S., aged 62, who had had diathermy excision of a carcinoma of the right side of the floor of the mouth. He had been bleeding intermittently for three days. The right external carotid artery had been tied forty-eight hours previously, but hæmorrhage continued. Blood was streaming from his mouth, and he was blanched. Both lingual arteries were tied by the classical method. The hæmorrhage ceased forthwith. The patient recovered and returned home.

Technique.—The head is extended and turned to the opposite side. The anæsthetist is requested to keep the head well up and the lower jaw fixed. The incision is shown in *Fig.* 1107. It is made from a little below the angle of the jaw to below the symphysis

Fig. 1107.—Ligature of the lingual artery: the incision.

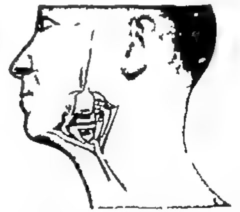


Fig. 1108.—The submandibular gland is dissected free and retracted upwards. The tendon of the digastric is retracted downwards.

menti, convex downwards. Its centre is just above the great cornu of the hyoid bone. The incision is deepened through the platysma and fascia until the submandibular gland is dislocated from its bed and retracted upwards over the margin of the jaw. The tendon of the digastric muscle and its two muscle bellies are now defined. A blunt hook is passed round the tendon, which is drawn downwards and towards the surface, a very important step in the operation (*Fig.* 1108). The hyoid bone carrying with it the hyoglossus muscle can now be made out. Crossing the hyoglossus muscle are the hypoglossal nerve and its accompanying vein. A director is passed under the hyoglossus muscle, which is divided on to the director near its insertion on the hyoid bone. Beneath the hyoglossus will be

found the lingual artery (*Fig* 1199), which is divided between ligatures. It is not necessary to suture the hyoglossus muscle. The submandibular gland is allowed to fall back and the wound is sutured.

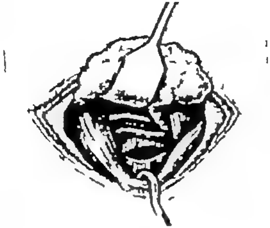


Fig. 1199.—The lingual artery is exposed by dividing the hyoglossus muscle. Hypoglossal nerve, vena comitans, and lingual artery are shown.

EXPOSURE OF THE CERVICAL ŒSOPHAGUS AND THE PHARYNX (LATERAL PHARYNGOTOMY)

Considerable trepidation exists concerning exposing the cervical œsophagus and the pharynx. Nevertheless this operation has a considerable field of usefulness—for instance in instrumental perforation or perforation by a foreign body e g a sharp bone, of the pharynx or the cervical œsophagus, and in cases of a tooth-plate or other foreign body firmly wedged in the upper œsophagus also there must be occasions when an œsophagoscope is not available. By way of a lateral pharyngotomy a foreign body in the œsophagus

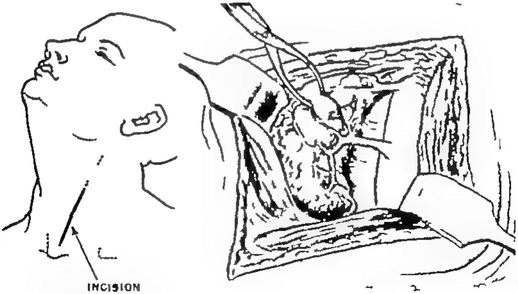


Fig 1200.—The middle thyroid vein prevents rotation of the lateral lobe of the thyroid medially

can be removed with the fingers, a long hæmostat, or a sigmoidoscope depending on how far down the œsophagus it is impacted There are many isolated hospitals which, while possessing a sigmoidoscope are hundreds of miles from the nearest œsophagoscope

Anæsthesia.—When the patient has received suitable premedication unilateral cervical block anæsthesia (see p 843) is perfectly satisfactory

Operation.—If a choice exists (i.e there are no clinical or radiological signs localizing the lesion to one side) usually the left side of the neck is chosen because the œsophagus

bears to the left. A long incision is made parallel to the anterior border of the sternomastoid muscle. The superficial fascia is divided and the muscle is retracted laterally The fascia and muscle-fibres of the sternohyoid and sternothyroid muscles are separated. The carotid artery and jugular vein are also gently retracted laterally By blunt dissection the lateral

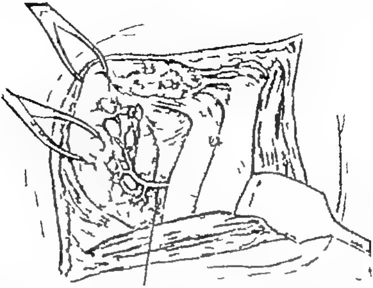


Fig. 1201.—Di ision of the middle thyroid ein allow the thyroid gland to be lifted up and rotated medially when the upper part of the œsophagus will come learly into view Occasionally the inferior thyroid rtery tethers the gland and the latt vessel requires division also.

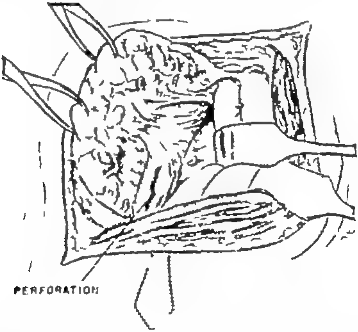


Fig. 1202.—H. L. Pearse successful case The œsophagus was perforated by clam shell. The perforation was sut red. The dotted line show the extent f the extra asation l t the superior mediastinum, and exemplifies the necessity for the free drainage described in the text

surface of the thyroid gland is exposed. It will be found that the thyroid gland is held down by the middle thyroid vein (*Fig* 1200). After ligation and division of this vessel the lateral lobe can be lifted up and rotated medially This may be all that is required to expose the œsophagus and the phary some instances the inferior thyroid artery may prevent a proper di play of the œ in the lower part of the wound. When

this is the case the artery should be divided between ligatures well away from the thyroid gland (*Fig* 1201). After this has been accomplished splendid exposure of the upper inch or two (2.5–3 cm.) of the œsophagus and the lower part of the pharynx is obtained. Before opening an intact œsophagus the space behind the œsophagus (which can be freely entered by the finger) and the lower part of the wound leading to the superior mediastinum should be packed lightly with petroleum-jelly gauze. This packing should be left in place and if the wound is drained freely and antibiotics are administered the development of mediastinitis, which formerly was much dreaded, is exceedingly improbable. In cases of perforation where the space is infected already very free drainage both behind the œsophagus as well as towards the superior mediastinum, will give the patient a chance of survival that in other circumstances would be denied to him (*Fig* 1202). "The sun must never rise or set in perforations of the alimentary canal without an attempt at relief" (Willy Meyer)

WOUNDS OF THE THORACIC DUCT

Wounds of the thoracic duct are very rare and those recorded have been incurred during an operation on the left side of the neck particularly for extirpation of neoplastic lymph nodes and thoracic œsophagectomy. The injury may be noticed at the time of the operation, or later when chylorrhœa develops. It is doubtful if division of the duct, or alternatively its ligation, is necessarily fatal or even permanently injurious to health. No doubt this is accounted for by the multiple communications between the main duct and the venous system. In at least 30 per cent of cases the main outlet of the thoracic duct is duplicated, which helps us to appreciate why division or ligature of what is presumably a vital structure may be of no consequence.

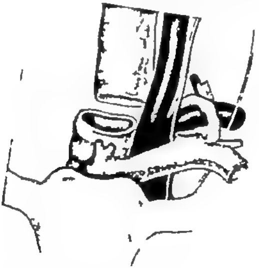


Fig. 1203.—The termination of the thoracic duct

When the accident is not recognized at the time and chyle pours from the cervical wound, firm pressure by pad and bandage may be tried. When the chylorrhœa is not excessive this simple measure is effective. Should the leakage continue it means that the main and possibly the only effective outlet of the thoracic duct has been severed. After the patient has had a feed of cream, preferably containing a green[1] or purple dye used in confectionery to aid in the identification of the duct the wound must be reopened.

R Bucknall's Case.—

The patient was 54 and weighed 16 st. A mass of tuberculous lymph-nodes was dissected from the left supraclavicular triangle. After operation chyle poured from the wound. Each day between two and three pints leaked away the burly patient rapidly lost strength and his general appearance caused grave anxiety. On the sixth day as the discharge showed no signs of abating, operation was decided upon. He was given a pint of cream, and three hours later the wound was reopened. There was no difficulty in finding the thoracic end, which was discharging the creamy

[1] When ordering, ask for confectioners dye D-C6.

fluid, and the distal end was soon located, but it was found impracticable to unite them. Each was ligated. After the operation the patient developed oedema of the head and neck, which may be attributed to the chyle passing through the right lymphatic duct. A few months later he died of miliary tuberculosis. In some way the division or ligature of the duct may have distributed the disease.

I had a similar case following extirpation of malignant lymph nodes. After a feed of cream it was quite simple to locate the duct, but it was found difficult to ligate even with the finest silk—the ligature cut through. Finally a ligature appeared to hold well. Forty-eight hours later the chylorrhoea was as bad as ever. The wound was again opened and packed firmly with gauze soaked in flavine solution. Pressure was maintained for four days by a pad and a bandage passing under the opposite axilla. This acted admirably. The patient recovered and resumed his duties as a postman for a short time only to succumb to secondary growths in bones. The experience of the case demonstrated the futility of expecting a pad and bandage to control a leak in a concavity such as the supraclavicular triangle. The wound must be opened and the concavity filled with packing before exerting external pressure.

In cases of profuse chylorrhoea, to await the possibility of spontaneous closure of the severed duct is to risk (*a*) emaciation, and (*b*) duct friability. For these reasons George Crile, jun., has come to the conclusion that *early* ligation is *the* treatment for this condition.

See also Chapter XCIII.

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CHAPTER LXXI

THE THYROID

PRE-OPERATIVE EMERGENCIES IN THYROTOXICOSIS

Thyroid Crises.—Occasionally a patient with a toxic goitre is admitted in a thyroid crisis. Such a crisis can be looked upon as a hyperacute phase of thyrotoxicosis. Rather suddenly the patient passes into an intensely toxic confused state with a pulse-rate of 150–200, and increasing mental symptoms. Usually there is considerable pyrexia (up to 106° F. (41.1° C.)). Frequently vomiting and diarrhœa are in evidence.

Treatment.—

Ice Packs.—If the temperature is in the region of 103° F. (39.4° C.) ice packs to the limbs are ordered. If the temperature is 104° F. (40° C.) or more, an ice pack to the whole body except the chest wall sometimes tides the patient over the crisis. The precordial region is a useful situation upon which to apply an ice pack, but that part of the chest wall overlying the lungs should be avoided. In less severe cases alcohol sponge baths suffice.

Intravenous Iodine[1] is the mainstay of treatment. As soon as possible, administer a sterile solution of potassium iodide, gr. 1 in 5 ml. of normal saline solution, which is repeated twice daily, or Lugol's solution 20–40 min. (1.3–2.5 ml.) up to 100 min. (6 ml.) of this solution can be given intravenously in the course of 24 hours. It should be administered diluted in normal saline solution.

Oxygen must be administered, nasal catheters being employed if the patient is intolerant of a mask.

Sedation.—Larger doses of morphine, barbiturates, or chloral hydrate are necessary than for other acutely ill patients.

Intravenous Dextrose Solution is possibly of value, but should be given with the greatest care. It must be realized that the heart is feeble and to overburden it may have disastrous results. Dextrose solution should, however, be given if the patient vomits fluids given by mouth. As it is probable that failure of liver function plays a significant part in the production of reaction, the administration of plenty of dextrose by one or other route is essential.

Antibiotic Therapy is given to avert intercurrent infection.

Digitalis is ordered, if required. Thyrotoxic patients have an increased tolerance to this drug.

ACTH.—In those patients who do not respond quickly to iodine therapy, 20–30 mg. of ACTH intramuscularly 6-hourly is given for 6 days, the amount being regulated by the eosinophil count and 17 ketosteroid output. Cortisone is substituted when the steroids fall. It is given in doses of 200–300 mg. daily. As soon as the crisis is controlled, the patient should be given a course of one of the antithyroid drugs in preparation for subtotal thyroidectomy.

COMPLICATIONS OF THIOTHERAPY

1. Compression of the Trachea.—Thiotherapy causes the thyroid gland to become larger and harder; therefore this form of pre-operative treatment should be avoided in cases of retrosternal goitre, and in any case where a toxic adenoma or a nodular goitre can be demonstrated radiologically to be causing compression of the trachea. Its use in such cases can bring about a disastrous degree of respiratory obstruction.

2. Myxomatous Infiltration of the Vocal Cords.—In addition to causing the gland to become larger (thiouracil goitre), overdosage with antithyroid agents also induces myxœdema which, in the early post-operative phase, is liable to produce thickening of the vocal cords and œdema of the glottis, necessitating tracheostomy, as occurred in three patients at the Lahey Clinic (R. B. Cattell).

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[1] The action of antithyroid drugs is too gradual for their successful employment in a crisis.

3. **Agranulocytosis**, a condition in which there is an absence of or a great diminution in, the granular form of leucocytes. It rarely develops unless the dose of thiotherapy has been excessive, and *usually during the third or fourth weeks of treatment* The leucopenia of severe thyrotoxicosis is suddenly transformed into agranulocytosis, with such catastrophic rapidity that repeated blood-counts are not an adequate safeguard. Sternal marrow examinations give more reliable information than an investigation of the blood, and should be carried out if agranulocytosis is suspected, and during its treatment. Any patient undergoing thiotherapy who develops a sore throat, pyrexia, and malaise, sometimes associated with a papulomacular rash, or one of the rare symptoms—conjunctivitis, enlargement of the salivary glands, enlargement of lymph nodes, arthralgias or hæmaturia—should be admitted without delay for further investigation, the diagnosis of agranulocytosis being presumed until the contrary is proved If agranulocytosis is present, the thio-agent is stopped forthwith. Penicillin and streptomycin are given as a prophylaxis against infective complications. Pentose nucleotide is administered intramuscularly in doses of 10 ml. of an 8 per cent solution 6-hourly to stimulate the formation of granulocytes. In severe cases blood transfusion is necessary No sulpha drugs or chloramphenicol must be given, as both these preparations may give rise to agranulocytosis. In spite of treatment the condition proves fatal in about a quarter of the patients affected.

COMPLICATIONS DURING THYROIDECTOMY

Hæmorrhage.—As a rule the hæmorrhage is less dangerous than the damage done by excited attempts to control it. Hæmostats applied blindly in the attempt to arrest bleeding from an artery are liable to result in the internal jugular vein being torn and more hæmorrhage The recurrent laryngeal nerve is also imperilled in like circumstances, especially when the hæmorrhage comes from the inferior thyroid artery or the middle thyroid vein.

Arterial Hæmorrhage.—Most frequently furious arterial hæmorrhage comes from a severed *superior thyroid artery* which always retracts high into the neck. As a preventative measure it is strongly advised to place two ligatures on the proximal end prior to division of this artery The more proximal of these ligatures embraces a small portion of the upper pole, which is divided beneath it. Slipping of this artery should never occur if the precaution *is taken of preserving a small tip of the upper pole (F de Quervain). When the accident has* occurred, the first thing to do is to control the hæmorrhage by direct digital pressure on the region of the bleeding This is followed by gauze packing which will stay the hæmorrhage thereby giving the opportunity to reflect the skin-flap farther upwards and divide transversely the pretracheal muscles of that side of the neck, if that step has not been taken already Undivided pretracheal muscles should be severed transversely really high, viz., on a level with the upper third of the thyroid cartilage, and the sternomastoid muscle is retracted laterally When the pretracheal muscles have been divided earlier in the operation the midline split in the muscular layer should be extended upwards, so as to enable the operator to raise an L-shaped flap of muscle. In either event, in the depths of the wound the superior thyroid artery will then soon be discovered, if it is bleeding Before removing the packing the external carotid artery can be compressed, which will diminish the hæmorrhage The bleeding artery having been displaved and secured by a hæmostat, it is ligated under vision.

Hæmorrhage from the *inferior thyroid artery* is especially dangerous, not from loss of blood, but because of the proximity of the bleeding vessel to the recurrent laryngeal nerve The artery enters the thyroid gland on its posterolateral surface and if the finger is passed behind the remnant of the gland, and the remnant is compressed against the trachea, the bleeding will be arrested. The inferior thyroid artery is a branch of the subclavian artery and cannot be controlled by pressure on the carotid artery Because of the danger of damage to the recurrent laryngeal nerve it is safer to ligate the main trunk of the artery well away from the bleeding point. It should be noted that the site at which the ligature should be applied to the inferior thyroid artery lies behind the external carotid artery

Venous Hæmorrhage.—During an operation upon a large goitre which is obstructing the deep veins of the neck, injury to the anterior jugular veins is liable to result in copious hæmorrhage The application of a lateral ligature to a vein of the neck as has been emphasized on p. 852, should always be avoided. Too often the ligature is blown off The correct procedure is to apply a hæmostat above and below the opening and divide the vein completely and ligate both ends.

One of the most frequent causes of hæmorrhage during thyroidectomy is tearing of the middle or inferior thyroid veins. This occurs especially in elderly patients, where these vessels are extremely friable and can be torn easily by blunt dissection of the capsule, or when elevating a retrosternal goitre from its bed. The middle thyroid vein may be torn from the internal jugular vein. In such an event it is necessary to tie the internal jugular above and below the rent. In the case of a retrosternal goitre a torn inferior thyroid vein retracts towards the mediastinum and great care must be exercised not to injure a recurrent laryngeal nerve. A pack will temporarily check the bleeding but it is seldom permanently effective.

If possible it is advisable to locate and tie the middle and inferior thyroid veins before or while elevating the thyroid from its bed. A golden rule to prevent tearing of a vein is to keep the field of operation clear of hæmostats. "An old fox always cleans up his steps as he goes" (Charles Mayo)

One great advantage of performing thyroidectomy under cervical nerve-block anæsthesia is that it permits the patient to cough at the completion of the resection before the incision is closed, thus causing an insecurely ligated vessel to bleed.

Inadvertent Tracheostomy.—A distressing complication in thyroid surgery is inadvertently making a hole in the trachea during operation. The finger should immediately be placed over the opening and held there until the wound is absolutely dry. When an intratracheal tube is in situ, the anæsthetist can so increase the gas pressure in the trachea that blood is not inspired—in which case the emergency loses much of its terror. Operators who have had experience with this mishap have found that rather than to close the opening with sutures it is safer to take a suitably sized piece of rubber tubing and place the end just inside the trachea and suture it snugly there with fine catgut (*Fig.* 1204). This eliminates the possibility of escaping air or bacteria causing serious subcutaneous or mediastinal emphysema or infection. The tube, which is brought out through a special stab incision in the flap, should be left in position at least four days, to allow sealing of the tissues around it (B. T. King). The thyroidectomy incision is drained freely down to the trachea, and antibiotic therapy is administered.

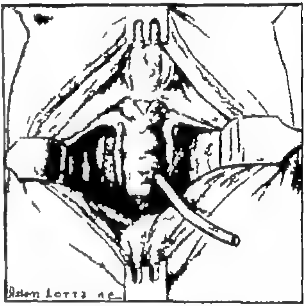
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Fig. 1204.—If the trachea has been opened it is safe to put a small rubber tube just inside the opening and to suture it there with fine catgut. (*After B. T. King.*)

POST-OPERATIVE COMPLICATIONS

Deep Arterial Hæmorrhage.—Respiratory obstruction brought about by the occurrence of arterial hæmorrhage beneath the pretracheal muscle layer (sternohyoids and sternothyroids) comes on without warning usually within six hours after operation. The pressure evoked by bleeding from the superior or inferior thyroid artery into this virtually closed space may approach that of the systolic blood pressure: little wonder that the trachea is compressed.

The patient holds her head in a peculiar fixed position and finds it impossible to move the head without exaggerating the symptoms of suffocation. Although swelling can seldom be seen, palpation of the neck will reveal that the rings of the trachea cannot be felt: instead there is a sense of firmness and a forward projection of the skin flap and the underlying strap muscles. So sudden and severe is this type of respiratory obstruction that on frequent occasions it will not be possible to get a doctor in time. Consequently it is of paramount importance that the nurse in charge, as part of her training, should be instructed that the correct treatment of sudden post-thyroidectomy respiratory obstruction is for her

to cut the skin sutures or remove the clips, sever the muscle sutures, spread the muscles, remove clots, and apply pressure to the bleeding vessel with the fingers over a gauze pack, care being taken to avoid compression on the trachea, until surgical aid can be obtained. In desperately urgent circumstances such as these it is more than justifiable to carry out these measures with unsterilized hands.

As soon as possible the patient is taken to the operating theatre and under good illumination and with adequate retraction of the strap muscles (which are divided transversely as necessary) the bleeding vessel is secured and ligated. The method of displaying the retracted proximal end of a bleeding superior thyroid artery has been described on p. 804. Early in the course of these life-saving measures blood transfusion or the infusion of a blood substitute is commenced.

Infrequently, and when deep hæmorrhage is more gradual, as would be the case when bleeding comes from a tributary of the internal jugular vein, evacuation of blood and clot either does not relieve, or relieves only partially, the laryngeal obstruction. The explanation is that blood and clot around the trachea and larynx have so compressed the efferent lymphatic vessels that œdema of the glottis has ensued; this is particularly liable to occur when some degree of compression deformity of the trachea is present. Therefore should

A B

Fig. 1203.—A, Tension hæmatoma deep to the pretracheal muscles; B, Escape of blood into the subcutaneous plane occurs if a small gap is left unsutured deliberately. (*After I. Riddell.*)

evacuation of blood and clot fail to relieve the respiratory obstruction completely, the surgeon should not hesitate to perform tracheostomy.

If an opening in the lower part of the pretracheal muscles and fascia is left unsutured deliberately, asphyxia or indeed dyspnœa from a deep hæmorrhage after thyroidectomy cannot occur (*Fig.* 1203 B).

Superficial Hæmorrhage.—In as far as urgency and danger to life is concerned, superficial hæmorrhage is the very antithesis of hæmorrhage beneath the pretracheal muscles. Usually the bleeding comes from a subcutaneous vein, and causes a soft hæmatoma beneath the skin-flap and perhaps bluish discoloration of the skin. While in all probability it is necessary only to remove a stitch and evacuate the blood, it is a better practice to give the patient a sedative (not morphine), reassure her, and have her sent to the operating theatre. If necessary two or more stitches can then be removed, and perhaps a bleeding vessel will be seen, and can be secured. Clot can be evacuated better in the operating theatre, asepsis is assured, and the skin-flap can be approximated around a small drainage tube. In any doubtful case it is advisable to open the wound and make certain that all bleeding is controlled.

TRACHEOSTOMY AFTER THYROIDECTOMY

The time to do a tracheostomy in a post-thyroidectomy patient with breathing difficulty is when one begins to wonder whether or not it should be done. (Frank Lahey.)

Indications.—Four outstanding conditions that call for tracheostomy in these circumstances are:

1 Post-operative œdema of the glottis.

2 Post-operative hæmorrhage beneath the pretracheal muscles, incompletely relieved by re-opening the wound.

3 Bilateral abductor paralysis of the vocal cords.

4 Scabbard trachea. As a rule once the pressure of the enlarged thyroid is removed the rings of the trachea spring open sufficiently for adequate respiratory exchange. Should doubt exist at the time of the operation as to whether the diameter of the trachea will suffice it is better to carry out the additional operation than to run the risk of having to perform it later.

Usually it is during the night that post thyroidectomy respiratory inadequacy becomes severe enough to demand tracheostomy and it is during the first three nights following operation that the emergency situation arises most often. It is during the night that the patient is likely to receive sufficient sedation to slow respiration and this adds to her difficulty in getting sufficient air. It is during the night that cyanosis is so difficult to detect, because of dimmed artificial lighting. It is during the night that the nursing staff alone are responsible for raising the alarm. It is during the night that frequently the most junior member of the surgical team is called to see the patient. For these reasons only too often tracheostomy is postponed until morning and, if the patient has not expired in the mean time is performed too late. There are few conditions where self recrimination is more bitter than to realize too late that the simple expedient of tracheostomy would have saved the patient's life. This is more especially so in cases of œdema of the glottis, for in these relatively common cases the onset of compelling obstruction is slow and gives time for tracheostomy to be undertaken in the operating theatre.

On examination if the signs are advanced such as indrawing of the supraclavicular fossæ or the intercostal spaces, or if the patient is cyanotic and the respirations laboured no question arises concerning the need for tracheostomy. Should the patient be seen at a less advanced stage an audible stridor is a highly suspicious sign that calls for indirect laryngoscopy. Should such an examination show that the airway is encroached upon by œdema or if there is limited motion of the vocal cords, tracheostomy must be performed at once but in this instance there is time to take the patient to the operating theatre.

A. M., a male aged 61 had a hard uniform enlargement of the thyroid gland. He made light of the swelling in his neck, but kept harping on a fear of choking which, he said, had haunted him for several months. A laryngologist whom he had consulted had assured him that no laryngeal obstruction existed. Before submitting to thyroidectomy he consulted a second laryngologist, who reaffirmed the absence of any laryngeal involvement.

Total thyroidectomy was performed. The goitre was a large one and extended into the superior mediastinum. It was exceedingly resilient, and its texture suggested a carcinoma or possibly Hashimoto's disease. Considering the difficulty of the operation and the temperament of the patient it was a relief to find him in excellent condition the next day. Later that day he complained of his fear of choking. There appeared to be some mucus in the larynx, and an inhalation of tinct benzoini co. to be followed by oxygen, if necessary was ordered. The next day he was visited at frequent intervals by the house surgeon and two experienced general practitioners interested in his case all of whom were convinced that there was no respiratory obstruction and that his symptoms were due to his obsession. The last practitioner to see him had ordered ¼ gr (16 mg.) morphine and also nasal oxygen.

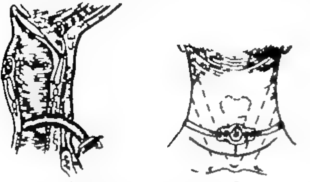
At 3.30 a.m. the telephone bell rang, and I was told that the patient who had been sleeping awoke suddenly became violent and died in a few minutes. At the inquest the pathologist stated that death was due to œdema of the glottis, and a section of the gland revealed carcinoma of the thyroid.

This case illustrates forcibly two mistakes: firstly morphine must never be given to a patient with actual or threatened respiratory obstruction and secondly the advice of the late Frank Lahey should have been followed—"If doubt exists," he wrote "it is infinitely better to perform an occasional unnecessary tracheostomy than to lose a patient because of failure to take this precaution."

Technique of Post thyroidectomy Tracheostomy.—In very urgent conditions neither should the head be extended nor the patient placed in the supine position, both of which increase respiratory distress. In this instance tracheostomy can be conducted easily with the patient in a semi-sitting position. Any form of general anæsthesia must be forbidden. What is most important is that unless the thyroidectomy skin incision was placed relatively high in the neck, which is unusual 1 per cent procaine should be injected into the skin of the middle line of the flap. After three of the most centrally placed skin stitches have

been removed, the skin flap is picked up in dissecting forceps and slit directly upwards in the midline for a short distance with scissors (*Fig.* 1206 A). More procaine is injected into the muscles, and the stitches uniting these are cut. The bared trachea makes tracheostomy a particularly simple operation and swiftly it transforms a perilous state into one of comparative safety. If it can be obtained in time, the injection of 10 min. (0.75 ml.) of 2½ per cent solution of cocaine into the trachea before it is opened is of great advantage.

Following the insertion of a tracheostomy tube, the cavity formerly occupied by the thyroid is packed lightly with petroleum jelly gauze. This is of especial importance if the goitre was retrosternal. The end of the gauze is brought out of the wound, which is closed around the tube, leaving a separate exit for the gauze. Antibiotic therapy is given to prevent mediastinitis (which is unusual if the cavity is packed as directed) and pneumonia, which is the complication most to be feared.



A B

Fig. 1206.—A, Improperly-placed tracheostomy tube. It has been inserted through a low thyroidectomy incision; B, Correctly-placed tracheostomy tube. The skin-flap has been split vertically in the middle line to accommodate the tube. (*After Frank Lahey and W. B. Hoover.*)

Tracheostomy at the Time of the Thyroidectomy is necessary when it is possible that both recurrent laryngeal nerves are damaged. Occasionally it is also necessary in cases of scabbard trachea, when it is judged that the diameter of the trachea may prove to be inadequate. If the patient is under endotracheal anesthesia the opening is made in the trachea, after which the endotracheal tube is withdrawn only far enough to permit the tracheostomy tube to be inserted. If the obturator is left in the tracheostomy tube the anesthetic can be continued until the operation is completed. In cases of retrosternal goitre, if the site of the tracheal narrowing is below that which can be reached by a standard tracheostomy tube, and no specially long tube is available, a tracheostomy tube is improvised from a suitable piece of firm rubber tubing or a rubber catheter with the provision of a terminal opening (see p. 841).

INJURY TO THE RECURRENT LARYNGEAL NERVES

Unilateral Injury shows itself by a whispering voice or by temporary aphonia. A most reliable sign that one vocal cord is not functioning is to ask the patient to cough; instead of the usual explosive sound of a cough there is a sound of rapid exhalation, as though the patient was attempting to clear the throat. Sometimes slight stridor is present.

Owing to failure of the glottis to close during swallowing, paroxysms of coughing of the type referred to may occur while drinking, due to the fluid entering the larynx; such attacks are temporary. *Except that excessive bronchial secretions tend to accumulate,* unilateral injury to a recurrent laryngeal nerve does not endanger life, and no particular treatment, except, perhaps, postural drainage, is required. Although it may take six months or more, in 50 per cent of cases complete recovery of the nerve ensues (V. Riddell). In the remainder good compensation can be expected eventually from hypertrophy of the muscles activating the contralateral cord.

Bilateral Injury.—Often the first sign of bilateral injury to the recurrent laryngeal nerve is the sudden development of inspiratory stridor. Most frequently such respiratory distress comes on at varying times after thyroidectomy, and is preceded by aphonia, which sometimes passes off to the extent that the patient can whisper. Once inspiratory stridor has developed, it tends to worsen as a result of oedema of the vocal cords. Should doubt exist as to whether both vocal cords are paralysed, ask the patient to count from 1 to 21 without taking a breath, and to finish by taking a deep breath. When the vocal cords are paralysed a crowing type of inspiratory stridor is produced. On no account administer morphine in the endeavour to calm the patient and induce sleep; too often, morphine given to a patient with abductor paralysis causes her quietly to cease to breathe, and even if tracheostomy is then performed it is too late to resuscitate the patient. If the patient

has inspiratory stridor persistent dyspnœa or a feeling of impending suffocation, it is safer to perform tracheostomy without delay

In over half the cases of bilateral paralysis of the vocal cords recovery ensues, although it often takes many months. Removal of the tracheostomy tube (with the usual preliminary precautions) is governed entirely by the state of the vocal cords as long as they are immobile it must be retained If permanent paralysis persists, the affected vocal cord remains completely immobile on attempted phonation and is thin and withered.

Concomitant Hypothyroidism and Hypoparathyroidism—Ranke and Holinger studied 100 patients with vocal cord paralysis following thyroidectomy In addition to the lesion of the recurrent laryngeal nerve or nerves, thyroid deficiency was found in 31 per cent and hypoparathyroidism in 16 per cent. Hypothyroidism and hypoparathyroidism accompanied bilateral paralysis more than twice as often as unilateral paralysis of the vocal cords. Therefore, in due course, in all cases of recurrent laryngeal nerve paralysis investigations should be carried out to determine whether thyroid and/or parathyroid deficiency are present.

Lesion of a Superior Laryngeal Nerve.—The terms laryngeal œdema and post operative tracheitis have been employed to explain hoarseness occurring after thyroidectomy when it is not possible to demonstrate a lesion of one of the recurrent nerves. Usually the symptoms disappear in a few weeks, but in some cases there is a permanent slight change in the voice. The laryngeal picture of the injury which results in paralysis of the cricothyroid muscle is a partially relaxed cord that cannot be adducted completely (Moran and Castro)

TRACHEOBRONCHITIS WITH ACCUMULATION OF MUCUS IN THE BRONCHIAL TREE

During the post-operative reactionary phase and especially when there has been damage to a recurrent laryngeal nerve, the elderly thyrotoxic patient after subtotal thyroidectomy sometimes becomes so enfeebled that she is unable to cough up mucus. Dyspnœa and often cyanosis follows, and the temperature rises. Attempts to expectorate become progressively weaker and fatal bronchopneumonia is imminent. Atropine is contra-indicated, and expectorants are useless. In such cases George Crile jun., recommends giving 7½ gr (0·5 G) of caffeine sodium benzoate, withholding all sedation and carrying out periodic postural drainage with the foot of the bed raised high upon blocks. By these means an astonishing amount of mucus pours from the mouth with remarkable benefit and a fall of the temperature. During the periods of rest from drainage, oxygen therapy is given. Aspiration through an endotracheal catheter or via a bronchoscope may become necessary if the methods detailed fail. Alternatively it is sometimes wise to perform tracheostomy which, in point of fact, is far less disturbing to these weak patients than bronchoscopy and it permits bronchial secretions to be sucked out over a long period of time.

PARATHYROID TETANY

A rare complication of thyroidectomy parathyroid tetany occurs most frequently from one to five days after operation, but occasionally mild forms are not recognized for several weeks. In 50 per cent of cases two or more parathyroids are found embedded on the specimen removed In the remainder it must be assumed that a like number of these little glands were damaged at operation. The first symptoms of parathyroid deficiency are tingling and numbness of the lips, nose, and the extremities, sometimes accompanied by circumoral pallor

Fig 1207.—The obstetrician's hand seen in parathyroid tetany

Chvostek's Sign.—With a percussion hammer gently tap the seventh nerve as it courses in front of the external auditory meatus. When tetany exists, the tapping of the hyper-excitable nerve provokes a brisk muscular twitch on the same side of the face.

Trousseau's Sign—A tourniquet is placed around the arm and the pressure is raised to 200 mm Hg If tetany is present, within 3–5 minutes typical contractions of the hand are seen. The fingers are extended, except at the metacarpophalangeal joints, and all the fingers and the thumb are adducted to produce the obstetrician's hand (*Fig* 1207)

In severe cases painful cramp of the hands feet, and indeed any of the muscles of the body occur Strong adduction of the thumbs is almost always present, and this, coupled with extension of the feet, constitutes the so-called carpopedal spasm, which typifies

parathyroid tetany. Occasionally spasm of the muscles of respiration results in severe dyspnœa, and the patient is not only in great pain, but is in mortal dread of suffocation. Blurring of vision due to spasm of the intra-ocular muscles is common: even if the symptoms are mild, cataracts are a frequent late complication of the condition.

Treatment.—The immediate treatment is to inject 10–20 ml. of a 10 per cent solution of calcium gluconate or calcium chloride[1] intravenously. The injection should be made very slowly, and it causes almost immediate relaxation of the spasms. A few minutes after the intravenous injection a similar injection of calcium gluconate is given intramuscularly to give a more prolonged effect.

Should the spasms make intravenous injection difficult, 5–10 ml. of paraldehyde can be injected intramuscularly 20 minutes before the intravenous injection of calcium.

In an unusually severe case it is necessary to repeat the dose until satisfactory control of the spasms has been obtained.

Maintenance treatment is then commenced, and the choice lies between parathyroid extract,[2] vitamin B_2, calciferol and oral calcium, and dihydrotachysterol. Each has advantages, special indications, and disadvantages, which are beyond the scope of this work, save to state that vitamin B_2 and oral calcium is the standard long-term treatment of hypoparathyroidism. In all cases treatment should be controlled by serum-calcium determinations *(normal 9–11 mg. per 100 ml. (4.5–5.3 mEq. per litre))*.

Fortunately, in over half the cases in about a month the tetany disappears spontaneously. In a few of the remaining cases it is found that treatment can be dispensed with after a longer period, but more usually it must be continued indefinitely.

POST-OPERATIVE THYROID CRISES

In spite of adequate preparation by rest and antithyroid drugs, post-operative crises occur occasionally, at times in circumstances where the pre-operative pulse-rate, the basal metabolic rate, and the general condition of the patient might be considered within the normal range of variation.

The treatment does not differ from that described for pre-operative thyroid crises. *In severe cases that do not respond quickly to these measures, hibernation treatment* has been advocated.

HÆMORRHAGE INTO AN ADENOMA OF THE THYROID

If a patient with a goitre is suffocating, one assumes—almost always correctly—that the goitre is the cause. Urgent dyspnœa may follow a sudden hæmorrhage into a cystadenoma of the thyroid. In the more severe forms death follows quickly unless surgical aid is forthcoming immediately. On being confronted with a case of impending suffocation due to a tense thyro-adenoma, do *not* at once attempt tracheostomy. To be of service the tracheostomy must perforce be a *low* tracheostomy (always a dangerous operation), the difficulties of which, on such an occasion, would prove almost insuperable. The immediate first-aid treatment is to *divide the deep cervical fascia*,[3] and thus allow the engorged thyroid tumour to bulge forward into the wound.

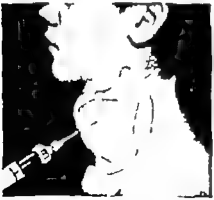


Fig. 1208.—Aspirating hæmorrhagic effusion into a thyroid cyst.

Aspiration of the cyst (Fig. 1208) is an excellent form of immediate treatment. Aspiration of such a cyst causing impending death is described by E. M. Eberts:—

A farmer, aged 34, was admitted to Montreal General Hospital with an enlargement of the neck and dyspnœa. At 3 a.m. he became worse. There was cyanosis, cold sweat on the face and restlessness. The respirations were noisy, pulse 100. The patient rapidly relapsed into complete unconsciousness.

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[1] If any escapes into the subcutaneous tissues, it causes necrosis. For this reason, calcium chloride must never be given intramuscularly.

[2] Parathormone, Eli Lilly & Co. Ltd., Basingstoke, Hants.

[3] The passage of an endotracheal tube is preferable—but in many instances of this extremely grave, unexpected emergency the tube cannot be obtained and passed in time.

An endotracheal catheter was introduced with immediate improvement. Oxygen was administered. At 3.30 a.m. the catheter became plugged with mucus. Suction was applied to the catheter followed by oxygen-air given down the catheter for one hour with slight improvement. At 4.30 a.m. a large aspirating needle was introduced into the swelling and 30 ml. of thick, chocolate-coloured fluid withdrawn. This led to an immediate improvement and in about five minutes the patient opened his eyes and answered questions. At 5.30 a.m. the endotracheal catheter was removed. By this time he had completely regained consciousness. At 10 a.m. the next day after further aspiration, the cyst-adenoma was enucleated successfully.

If aspiration is not effective or only partially so as might be the case if a coagulum were present within the capsule of the adenoma then operation must be hurried forward. The pretracheal muscles are divided and the thyroid gland exposed. As the thyroid bulges into the wound an adenoma will be seen or felt, in which case it can be punctured by a small incision. If the breathing then becomes tranquil, enucleation of the adenoma can be undertaken safely.

RETROSTERNAL GOITRE AS A CAUSE OF RESPIRATORY OBSTRUCTION

If an anteroposterior radiograph of the thorax is taken displacement of the trachea by a smooth shadow descending from the neck will be apparent (*Fig* 1209). When radiography has been omitted, and at operation a retrosternal extension of the goitre is discovered,

Fig 1209.—Retrosternal goitre causing displacement and compression of the trachea. (*Professor Carl Krebs, Denmark.*)

aspiration of the intrathoracic swelling is attempted under vision and guidance of a finger. Should this reduce the size of the swelling and the operator is inexperienced, the advisability of evacuation of as much as possible of the contents of the cyst and nothing more is probably the wisest course. More often unilateral subtotal thyroidectomy must be carried out. Division of the sternal heads of the sternomastoid aids considerably in the matter of access. If the superior pole and the lateral lobe are freed as in routine subtotal thyroidectomy and the isthmus of the thyroid is divided, delivery of the retrosternal goitre from the mediastinum is greatly facilitated. Indeed, often the intrathoracic portion of the goitre can be brought to the surface by gentle traction made on the cervical portion of the gland alone. If this is not successful a finger should be passed not in front of the retrosternal extension, but at the back and side in order to lever the goitre upwards. As the gland is delivered the lateral thyroid vein and branches of the inferior thyroid vessels are clamped cut and tied as they present themselves in the field. The operation should be practically bloodless if a careful dissection is performed and the main blood-supply of the adenoma is meticulously ligated before making any forcible attempt to withdraw the intrathoracic extension. When resecting the lobe a fairly generous slice of the posterior portion of the lateral lobe should be left to protect the recurrent laryngeal nerve. As a rule as soon as the goitre has been resected, thus removing the pressure the compressed trachea is restored to an adequate calibre. Serious collapse of the trachea probably seldom occurs except secondary to injury of the recurrent laryngeal nerve or nerves. As George Crile Jun.

has found in an experience of 100 of these cases, the operation is best conducted unde local or cervical block anæsthesia (see p 845). This ensures great gentleness and minimize the risk of post-operative pulmonary complications.

MULTINODULAR GOITRE CAUSING SUFFOCATION

Occasionally especially in goitrous districts, a multinodular goitre produces dangerous dyspnœa. The continuous compression of the sides of the trachea decreases its transverse diameter (*Fig* 1210) and if unrelieved, a time comes when this portion of the airway i but a mere anteroposterior slit (scabbard trachea)

In no circumstances whatsoever must primary tracheostomy be attempted, for reasons *given on p 870*. On the other hand the passage of an endotracheal tube usually brings the patient out of immediate danger and permits a general anæsthetic to be given. The only

Fig 1210.—Adenoparenchymatous goitre showing compression of the trachea. (*British Journal of Surgery*)

Fig 1211.—Delivering a massive enlargement of the thyroid on to the surface to prevent death from asphyxia. The mass is covered with a saline pad until arrangement can be made for removal of the goitre

really effective treatment is to undertake subtotal thyroidectomy and should the trachea be found in a dangerously compressed state, tracheostomy should be performed in addition. When the operator is inexperienced in this branch of surgery and particularly when the swelling *is mainly unilateral, the following procedure may prove valuable* having made a collar incision divided the pretracheal muscles, and searched in vain for a localized swelling deliver the offending lobe on to the surface This manœuvre sometimes brings about restoration of quiet respiration as can be proved by withdrawing partially the endotracheal tube *if such is in place*. If on delivery still no localized swelling can be found, the immediate treatment may cease at this juncture The goitre is left extruding from the *wound (Fig 1211)*, and after under running bleeding points with a ligature on a needle the mass is covered with a saline-soaked pad. The patient is returned to bed until her condition *has* improved and arrangements can be made for removal of the goitre

Occasionally delivery of the offending lobe or both lobes, fails to improve the breathing or makes it worse These are cases in which the trachea has been compressed into the shape of the sheath of a sword. In such a case to perform subtotal thyroidectomy is the only measure that can be recommended Only after the thyroid has been removed is it possible to *tell if tracheostomy is* required, in addition. As a temporary measure in extenuating circumstances, the following course might be justifiable. It was carried out with temporary benefit in a case of tracheal obstruction later proved to be due to an advanced carcinoma of the thyroid

After injecting local anæsthetic make a transverse skin incision just beneath the cricoid cartilage by picking up the skin vertically Perform laryngostomy by incising transversely the cricothyroid membrane Pass an endotracheal tube through the laryngostomy wound downwards past the obstruction. Place a safety pin through the tube and attach tapes, which are tied behind the back of the neck. In the case referred to a large gum-elastic urethral catheter was employed.

INFECTION OF A THYROGLOSSAL CYST

The peculiar liability of a thyroglossal cyst to become infected (*Fig* 1212) frequently results in misdiagnosis in favour of a collar-stud abscess connected with a breaking down pretracheal tuberculous lymph node As a rule incision and drainage should be avoided as this results in a thyroglossal fistula. With antibiotic therapy and even without it, the inflammation subsides, permitting extirpation of the cyst in the thyroglossal tract in due course. On the other hand, when the inflamed cyst is in or near the tongue—which is most unusual—if there is not a quick response to antibiotic therapy incision is more than justified. H E. Kay reported a case of a young man in whom œdema of the glottis and death resulted from infection of a thyroglossal cyst in this situation.

Fig 1212.—Acute inflammation in a thyroglossal cyst. Illustrating the tendency of the accompanying cellulitis t spread laterally and surround the neck like a necklace

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CHAPTER LXVII

COMPOUND FRACTURES OF THE EXTREMITIES

PRE-OPERATIVE TREATMENT

A compound fracture is a most urgent surgical emergency. Immediate operation is as imperative for this condition as for early perforated appendicitis.

First Aid.—Treatment of a compound fracture should commence at the place of the accident. A sterile dressing is applied to the wound, and, as a rule, a suitable dose of morphine is injected intravenously, but splintage alone sometimes ameliorates the pain adequately. Exceptionally there is considerable hæmorrhage from the wound; even so, the application of a tourniquet is unnecessary and harmful. What is required is a pad with a firm bandage over the wound. The limb should be splinted before the patient is transported to the nearest hospital; there is no better method of immobilizing the lower limb than by means of a Thomas's splint. Great care must be taken to ensure that the limb is not moved unnecessarily. First-aid workers should receive specific instructions on these fundamental points.

Prophylactic Therapy.—As soon as possible 500 000 units of penicillin and 0·5 G. of streptomycin are injected in order to combat common pyogenic infections. In addition it is imperative to inject intramuscularly 1500 international units of antitetanic serum, whether or not the patient has been inoculated with toxoid previously. Admittedly early excision of the wound is by far the most important means of prophylaxis against gas gangrene, but the additional precaution of injecting the contents of an ampoule (22,500 I.U.) of antigas-gangrene serum intramuscularly is worth while. In this connexion attention is drawn to the convenience of compound tetanus–gas-gangrene antitoxin (combined),[1] which ensures that neither of these safeguards is forgotten.

Treatment of Shock.—While loss of blood and shock, often due mainly to other injuries, sometimes necessitate postponement of operative treatment, in the majority of instances a compound fracture *per se* is not accompanied by profound shock, so that the sooner the patient is conveyed to the operating theatre the better. However, it should be the unwavering rule to take a sample of the patient's blood for grouping and cross-matching so that blood transfusion can be given without undue delay in necessary cases. This accomplished, a slow continuous intravenous infusion of a blood substitute is commenced in the ward; at any time during or after the operation, if the signs so dictate, the rate of flow can be increased. In this way delayed shock will probably be circumvented.

Regarding the need for blood transfusion, R. Clarke et al. found that the average blood loss was:

Tibia and fibula (some compound)	1·5 l.
Femur (closed)	1·0 l.

In all patients the pre-operative loss, if more than 2 pints (1·13 litres) and the operative loss (fairly accurately determined by swab weighing) should be replaced.

Radiography.—Radiographs of the entire length of the broken bone in two planes are highly desirable; they should be taken with a portable machine, either in the ward or in the operating theatre.

Obtaining Permission for Amputation.—As it is most inadvisable to examine the wound before it is uncovered in the operating theatre, when the radiograph reveals comminution, or there is reason to believe that mutilation of the soft parts is extensive, or indeed when the extent of the damage is as yet unknown, it is highly important to obtain permission for amputation in writing before commencing to operate. Explain to the patient and his relatives that every effort will be made to save the limb.

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[1] Parke Davis & Co. Ltd., Hounslow, Middlesex.

OPERATIVE TREATMENT

Anæsthesia.—Full general anæsthesia is necessary

The Question of the Advisability of Immediate Amputation arises.—A pulped limb with multiple contaminated compound fractures must be treated by suitable amputation. In cases of comminuted compound fractures or compound fractures complicated by extensive injury of soft parts, the decision whether or not to amputate sometimes can only be made after the wound has been opened in the manner to be described the demonstration of an intact main arterial trunk *can be the deciding factor in favour of conservatism.* The fact that the general condition of the patient will not withstand a prolonged operation sometimes weighs heavily in favour of a quick amputation. In cases of real doubt if a second opinion can be obtained without delay so much the better In the case of a foot that has been crushed producing multiple compound fractures of the tarsal and metatarsal bones, or where a contaminated compound fracture involving the ankle-joint is present so often when amputation is considered but not performed it transpires that after weeks *of suffering the patient has to have an amputation after all.* Therefore in the case of the foot, especially a dirty foot, if the question of amputation arises, carry out amputation somewhat more readily than in similar circumstances in other situations. After a well planned amputation there is a definite period of convalescence, at the end of which an artificial foot can be fitted to the stump

DETAILS OF AN OPERATION FOR A COMPOUND FRACTURE

In compound fractures of the lower limb the operation should, if possible be carried out on an orthopædic table or with the aid of a traction appliance. Either of these expedients will support the limb during excision of the wound provide traction to overcome shortening and leave the limb free for the application of a plaster cast.

The Bohler Screw-traction Apparatus for the leg consists of a rectangular tubular steel frame with uprights carrying crossbars (*Fig* 1213). The proximal crossbar is placed under

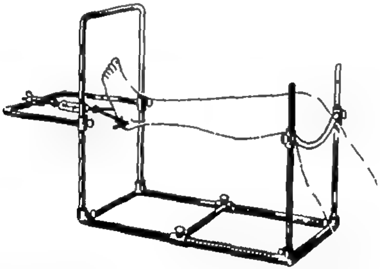


Fig 1213.—Bohler s screw traction apparatus for the leg

the flexed knee the distal crossbar carries a screw with a winged nut. To the screw is attached a hook, and to the hook is attached the stirrup of a Steinmann or other pin by means of copper wire with a spring balance intervening By tightening the nut increasing tension can be exerted on the leg and registered on the spring balance A third detachable upright (not shown) can be used to support the lower third of the leg which is hung from it by a bandage

This frame can be combined with adjustable supports for the thighs and the sound leg it is then used in conjunction with an ordinary pelvic rest. In this way the whole limb can be kept extended while traction is applied (*Fig* 1214) This is most valuable for reducing the fragments in a compound fracture of the femur and for applying a hip spica plaster cast at the conclusion of the operation.

When such apparatus is lacking the surgeon should reflect that desirable as is mechanical traction in many cases, a greater number of comparable compound fractures have been operated upon and reduced successfully with the aid of manual traction alone than all those where the surgeon has had the advantage of an orthopaedic table or a traction apparatus.

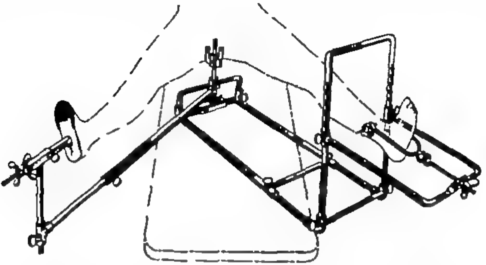


Fig 1214 —Bohler's screw traction apparatus with fitting for the sound limb making it comparable to an orthopaedic table The apparatus is used in conjunction with a pelvic rest.

He will therefore appoint an assistant whose sole duties are to hold the limb and apply traction when requested to do so. For the upper limb manual traction in all types of fracture is the method of choice

Before commencing the operation, compare the site of the wound with the radiological demonstration of the fracture, for an open wound near a fracture is not always connected with the site of bony injury Because the wound is small—a mere puncture—it does not imply that there should be a departure from the accepted principles of wound excision. The practice of sousing the wound with an antiseptic, and then treating the compound fracture as a closed fracture is archaic and reprehensible

Ablution of the Surrounding Skin.—A mop of gauze is held over the wound so that the skin can be cleansed up to the wound margin without further contamination of the wound itself The skin is shaved, and washed with 1 per cent cetavlon or soap and water using large gauze mops. Ether is used to remove grease. Hair should be shaved with a sterile razor The tendency at the present time is not to paint the skin with any antiseptic; this, however is a matter of personal preference but if a skin antiseptic is employed it should be colourless (alcohol or the colourless variety of metaphen) so as to avoid vitiating the distinctive features of non viable skin.

Bone is protruding from the Wound.—A comparatively thin, spiked fragment of bone should be cut off with heavy bone forceps flush with the wound as a first step. If the protruding fragment includes the whole or a large part, of the circumference of the shaft (*Fig* 1215), it should be cleansed with gauze well moistened with saline solution, but not dripping wet after which the excess of moisture is absorbed by dry gauze. Every precaution must be taken to see that fluid does not trickle from the bone into the wound. Tags of torn periosteum are excised and particles (usually silicon or carbon from road dirt) ingrained in the periosteum or the bone must be removed, a dental excavator being particularly useful for this work. On no account attempt to replace the bone until the wound has been excised. Rarely in cases of separation of an epiphysis the end of the diaphysis is forced out of the wound, when it is treated in the same manner

Excision of the Wound.—The more promptly and thoroughly excision of the wound is carried out the less is the probability of infection with its attendant train of suppuration, osteomyelitis, and non union of the fracture. In the case of injury of under 6 hours duration, excision of the wound is carried out in precisely the same manner as described on p. 134 Here only points in special relation to excision of a wound in the presence of a compound fracture will be considered

The wound is often more or less transverse. While the wound must be enlarged to give ample access to the bone ends and to be enabled to carry out adequate débridement, never enlarge the wound transversely and never enlarge it longitudinally in such a way as to convert a transverse wound into a +. The incisions to extend a transverse wound must be so placed as to make a step-like opening, viz. ⅃. This type of incision is particularly advantageous in an area where the skin is normally tight, such as over the anterior surface of the tibia. All recesses must be opened widely. Those in relation to the bone are often deep, necessitating considerable enlargement of the skin incision.

Small, completely detached fragments of bone found in the course of dissection are removed. *Fragments that have any soft tissue attachment whatsoever should be preserved carefully*. Larger loose fragments are removed and placed in a bowl of warm saline solution pro tem.

Attending to the Bone Ends.—Unless it was unavoidable, only after the débridement of the soft parts has been completed are the fractured ends of the bone touched, even with

Fig. 1218.—A, Compound fracture of the tibia with the upper fragment protruding from the wound. B, Wound excised and fracture reduced.

dissecting forceps. Before directing attention to the bone lesion, the surgeon covers the wound with a pack and removes the towels clipped to the wound edges. The surgeon, his assistant, and the instrument nurse change their gloves and, if time permits, their gowns also. A fresh set of instruments is put out, and the wound is redraped. By suitably retracting the bone the fractured surfaces can be seen, and this is highly desirable, for foreign matter, and particularly muscle, may be imprisoned between the surfaces. It is better not to attempt to cleanse the bone ends with gauze swabs—so often this results in the tearing of some of the cotton fibres, which are liable to become entangled in the spicules of bone.

Débridement being concluded, the wound is irrigated with normal saline solution delivered from a douche-can and tube. Usually a gallon (4.5 litres) or more will be required. It is advisable to irrigate too plentifully rather than too little, the stream being directed into every portion of the wound. Irrigation being completed, the wound is mopped dry and again a search is made for foreign material or devitalized tissue that has become apparent as a result of the irrigation. Particularly a search is made for loose tags of periosteum, which are snipped off. In cases where larger loose fragments of bone were removed temporarily, these are cleansed mechanically if they are obviously soiled, and replaced as accurately as possible. There is a definite risk of non-union if a gap is left between the ends of the bone. Provided the fragment or fragments are clean, they often act as a bone-graft. Should the wound become seriously infected, they still lead to some formation of new bone before being cast off as sequestra.

Reduction of the Fracture.—The fragments of the bone must be placed and held in adequate apposition and alinement. Satisfactory apposition of the fragments not only favours union of the fracture with minimum deformity, but aids in the prevention of infection of the wound. An *infected fracture is usually an incompletely reduced fracture*. With the fragments held in anatomical alinement, dead space in which contaminated blood-clot and

exudate can collect is minimized, and pressure of one or both ends of the fractured bone against the deep surface of the skin that might cause tissue necrosis, cannot occur. *In these ways accurate reduction inhibits wound infection.*

Reduction of a fracture is accomplished more easily in an open than a closed fracture, because the fragments are under visual control and muscle that was trapped between the fragments has been excised. To avoid further injury of the periosteum, as far as possible manipulation of the bone ends within the wound should be eschewed, reduction being effected mainly by the use of traction and external lateral pressure. No effort should be spared to obtain good alinement, for re-manipulation of a compound fracture within 14 days of its infliction must not be countenanced: the danger of spreading strictly localized infection is too great. When mechanical distraction is used to reduce the fracture, care must be exercised not to overdo the distracting force: non-union of the fracture is sometimes the penalty of too much traction. Volkmann's ischæmia can also arise from this cause. After reduction of the fracture the wound is irrigated and dried once more, swab-sticks are inserted into the various parts of the wound and sent for culture to determine what organisms are present and their antibiotic sensitivity. Ideally the report should read, 'Culture sterile.'

Difficulty in maintaining the Fragments in Good Alinement.—If the lower fragment cannot be maintained in good position without the aid of traction, and a Steinmann's or other pin has not been inserted already, the best site (*see Figs.* on p. 881) below the fracture is chosen and, after gloves have been changed, a pin is driven through the bone. When, in addition, the upper fragment cannot be stabilized, a pin can be inserted through the upper fragment 3 in. (7·5 cm.) proximal to the wound—a distance that will ensure that the bone through which it passes is sufficiently removed from the infected or potentially infected area. The pin or pins are later incorporated in the plaster-of-Paris cast.

Fig. 1216.—Oblique fracture of the tibia fixed by a single screw.

Internal Fixation.—While some orthopædic surgeons employ a bone-plate or an intramedullary nail to maintain apposition of the fragments in difficult cases (provided, of course, the case is an early one and débridement has been carried out meticulously), it would be most

Fig. 1217.—Bone screw of vitallium or stainless steel. Its tip is so shaped as to make it self-tapping.

inadvisable for anyone without considerable experience in the open reduction and fixation of fractures to attempt such procedures, with their ever-present danger of incurring or increasing the extent of osteomyelitis. *To place an encircling wire around an oblique fracture* that tends to slip has on many occasions served me well: the wire has been removed when the fracture has united. Circumferential wiring is recommended by Böhler, but is condemned by Sir Reginald Watson-Jones because it deprives the bone of some of its blood-supply. So it comes about that if circumferential wiring is not to be used, fixation by means of a bone-screw (*Fig.* 1216), or at the most two bone-screws, is the only procedure that can be advised in these circumstances. The vitallium machine type of screw with a self-tapping point (*Fig.* 1217) should be employed whenever possible. These screws are usually $\frac{1}{16}$ in. in diameter and before use a drill hole with a $\frac{1}{16}$-in. drill is required. A screw of the correct length is selected after measuring the drill-hole. It is better to employ a screw that is too long than one that is too short, and the screw should be turned until it is inserted fully; thereafter it is not tightened.

Concomitant Severed Tendons and Nerves.—No definite instructions can be given as to whether or not severed tendons and nerves should be sutured. If reduction of the fracture was difficult, if the wound was considerably contaminated, if the general condition of the patient is not all that could be desired, and if there are several tendons and nerves to repair, it is better to postpone a time-consuming apposition of these structures until at least a fortnight after the wound has healed soundly.

Should the Skin Wound be Closed by Sutures? Many surgeons believe that all compound fractures should be left open, that the limb should be immobilized and the wound permitted to heal by granulation. *A growing number have found that in civilian cases of under 8 hours duration* where débridement has been carried out meticulously primary closure is possible for most wounds; indeed in many cases of compound fracture the wound can be closed safely *if operated upon within 12 hours after injury provided there is absolutely no tension* on the suture line. It should be noted most carefully that the wound must never be closed in layers, but the skin and subcutaneous tissue are brought together in one layer by rather deeply placed skin sutures, preferably of stainless-steel wire tied not tightly. If there is even a suggestion of tension when a trial is made to bring the skin edges together unilateral or bilateral releasing incisions can be made, but they must be at least 1½ in (3.8 cm.) from the corresponding wound edge. This enables the skin edges to be approximated without any tension whatsoever and it has the additional advantage of providing drainage without leaving the bone exposed (*Fig* 1218). It has been said by some of those who advocate leaving the wound open in every case that the only objective of primary closure is to obtain a linear scar. This is far from the truth. Skin is the best covering for any clean wound; by suturing a clean wound secondary infection is prevented and scar tissue, in which tendons, in particular, can be encased, is minimized. It is unwise to attempt to close the wound by split skin-grafts at the time of the débridement: in these circumstances skin-grafts do not survive regularly and dead epithelium is a good medium for the growth of bacteria. Very occasionally it is an excellent practice to cover exposed bone and tendons by cutting and transposing a suitable pedicle-flap of skin with a broad base.

Fig 1218.—The use of lateral incisions to prevent tension on the suture line. If the skin between the incision and the wound is dissected up, lateral incisions provide drainage without leaving the bone exposed.

When the interior of the wound was contaminated with road or agricultural dirt, when the surgeon has any doubt concerning the effectiveness of the débridement, when the skin cannot be brought together without tension, unquestionably the wound should be left completely unsutured.

When it has been decided to leave the Wound Unsutured.—The wound is packed to the surface level with fine-mesh dry or petroleum jelly gauze with a firmness you would hold a lady's hand on greeting her.

Dressings and the Application of a Plaster Cast.—Whether or not the wound has been left open, the subsequent steps are the same. The wound and surrounding skin are covered with a *single layer of petroleum jelly gauze*. Upon this is superimposed a thin layer of dry gauze. The limb is then bandaged with gauze, followed by a thin layer of wool. Usually a plaster[1] cast is applied, and if it is, include the joint below and the joint above the fracture. The plaster cast is split before it has dried: this is a wise routine measure to prevent the occasional, but disastrous, occurrence of ischæmia. When the patient has been returned to bed the limb is elevated, and kept elevated for about a week.

A well-applied plaster cast immobilizes the limb more completely than any other form of splint, even when combined with efficient traction. With the limb, including the joint above and the joint below, encased, both movement of these joints and their activating muscles is prevented. *It is muscle contraction, and particularly joint movement above and below the wound, that squeeze infection into the lymphatic network.* Another advantage of plaster is that it readily absorbs exudates, rendering dressing of the wound unnecessary. Its one disadvantage is, should an anaerobic infection supervene, the wound is hidden from view—careful watch must therefore be kept for the development of general signs that point to this complication, rare as it is in civilian practice. If gas gangrene is suspected a radiograph (*see* p. 131) frequently shows gas in the tissues, even through a plaster cast.

Leaving the Wound alone.—In the absence of untoward symptoms, the plaster cast should *not be changed* for 3 or 4 weeks. Antibiotic therapy is continued throughout this

[1] A plaster slab wide enough to encircle threequarters of the diameter of the limb, and kept in place by a few turns of plaster bandage, is a good alternative. Should it be necessary to split the plaster it can be done with a pair of scissors.

period. Should the bacteriological report reveal that a penicillin-resistant organism is present the appropriate antibiotic is substituted for the penicillin. When the cast has been removed the wound is inspected in the operating theatre, with full aseptic precautions. The gauze is removed and either fresh petroleum jelly gauze inserted or if thought advisable secondary closure of the skin can be undertaken. The cast is then re-applied until firm bony union has occurred. Should the wound have been closed primarily the cast is removed at the end of 4 weeks, the stitches are removed, and the plaster is re-applied.

Evidence of Infection.—The first evidence of serious infection is pain. When the infection is due to gas gangrene the pain is sometimes excruciating and is accompanied by elevation of temperature and a disproportionate increase in the pulse-rate The fingers or the toes may become swollen or cyanotic. If any of these symptoms develop, remove the plaster reopen the wound if necessary and change or insert petroleum-jelly gauze If the infection is not due to gas gangrene, the plaster cast is re-applied and should penicillin and streptomycin have proved ineffective, these antibiotics are changed in favour of one of the tetracycline group

TREATMENT OF AN INFECTED COMPOUND FRACTURE WITHOUT GAS GANGRENE

Cases of compound fracture not admitted until more than 12 hours after the accident are not common in civil practice but cases where for one or other reason, infection becomes manifest after admission are less unusual In each instance the treatment is similar Enlargement of the wound, as necessary to provide unhampered drainage is the order of the day Major pockets are opened up, but tissue is not excised. Loose bone fragments, unless large are removed, as also of course is any foreign material that can be found. Specimens of the exudate are sent for bacteriological examination, culture and antibiotic sensitivity tests needless to say great trust is placed in correct antibiotic therapy Should it be absolutely necessary to employ a transfixion pin the transfixion should be as far away from the infected wound as possible The wound is packed very lightly with petroleum-jelly gauze dressings similar to those described already are applied, and the limb is immobilized in a plaster-of Paris cast The plaster should not be changed until the odour makes it compelling unless there is pain pyrexia increased pulse-rate, toxaemia, or progressive anaemia a combination of all or of some of these untoward symptoms indicates progressive invasion of the tissues.

In cases falling into the latter category the closed plaster technique must be abandoned, at any rate for the time being in favour of a splint with extension and moist dressings of the wound Carrel Dakin intermittent irrigation (see p. 130) was designed for such cases and, carried out faithfully is extremely effective

Carrel Dakin Treatment of an Infected Compound Fracture—Unless the sister in charge has had special experience in the method every detail of the treatment should be supervised by the surgeon or his deputy The skin around the wound must be protected from the commencement or it soon becomes inflamed by the irritating action of Dakin's solution. Tulle gras is the best material for protecting the skin. The distributing tubes are inserted into the wound with care and thought one is tucked beneath the bone and one is placed in the superior end of the wound it is exceptional for more to be required unless there are pocket present, which, after an efficient operation should not be the case The tubes are kept in place by gauze soaked in Dakin's solution. *No bandage is used.* A large piece of Gamgee tissue lined by four layers of gauze is made to encircle the limb, and kept in place by safety pins. The distributing tubes are brought out at convenient places, slot being cut in the Gamgee tissue to accommodate them they are anchored by small safety pins which do not penetrate any part of the tube

In cases where a good deal of slough is present in the wound irrigations with streptokinase and streptodornase (see p. 140) can be employed with advantage In grave infections the advantages of timely amputation must be weighed carefully

Treatment of Gas Gangrene —See p. 180

Pyogenic Skin Infection.—In cases of even mild infecti d where on removal of the plaster the skin is found to be covered wi llicles—a not uncommon finding—it i wise to employ a splint and dry area until the superficial infection has abated.

SKELETAL TRACTION BY PINNING

Skeletal traction pins should not be employed promiscuously for in a high percentage of cases a low-grade infection of the track occurs. If the pin track is close to the synovial and capsular reflexion of the joint, the degree of inflammatory change is sufficient to give rise to intra-articular adhesions.

Supracondylar Skeletal Traction is particularly liable to result in a stiffened knee joint, and should be avoided if there is an alternative. To insert the pin, a point is chosen on the inner side of the thigh two finger-breadths above the adductor tubercle (*Fig* 1219)

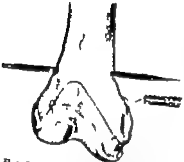


Fig. 1219.—Transfixion of the lower end of the femur

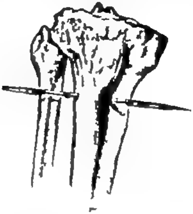


Fig 1220.—Transfixion of the upper end of the tibia.

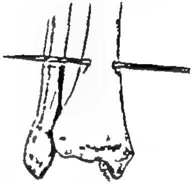


Fig 1221.—Transfixion of the lower end of the tibia.

Tibial Traction at the Level of the Tuberosity of the Tibia (*Fig* 1220) is relatively safe because even if slight infection does occur it is too remote from the knee joint to cause adhesions. The pin is inserted just below the tibial tubercle and about two finger breadths lateral to it. The fibula is not penetrated (*Fig* 1220). This site should not be used in children below the age of 14 because of late ossification of the nearby epiphysis.

Fig. 1222.—Transfixion of the os calcis, and (red) supracalcanean transfixion.

Fig 1223.—Supracalcanean traction pin in use. (Dr S. Morgan.)

Tibial Traction of the Lower Shaft 2 in. (5 cm.) above the Ankle (*Fig* 1221) is an excellent site free from joint complications. The pin is applied from within outward. The point of exit should be slightly anterior to the point of entrance, in order to avoid the fibula, which is not penetrated. This site can be used in children, for the epiphysis lies below the point of transfixion.

Calcaneal Traction (*Fig* 1222) is rather often required, because there is no alternative. It should not be used for longer than the bare minimum, because the ensuing mild infection is liable to involve the synovial reflexions of the subastragaloid joint and cause permanent limitation of inversion and eversion of the foot. Instead of inserting the pin through the os calcis, it may be inserted immediately above it (*see Fig* 1223, red dot) This has the

advantage that if infection does occur it will not be an osteomyelitis of the calcaneum (D
Moveas) A radiograph in which the latter method was employed is reproduced (*Fig* 12

Olecranon Traction is the most unsafe the elbow joint being particularly suscept to the formation of adhesions moreover it is hardly ever necessary

Steinmann s Pins are made of stainless steel, and vary in diameter from 2 mm. to 4 r One end is pointed sharply and the other is squared for the reception of a handle (*Fig* 12 The pin can be hammered through a cancellous bone like the calcaneus, but in most situations it is better to drill the bone first with a small wood twist drill of smaller diameter than

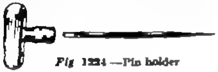


Fig 1224 —Pin holder

Fig 1225. — Böhler s swi el stirrup affixed to a Steinma n s pin.

Fig. 1226 —Whitchu Howell's pin.

the pin, and then insert the pin through this hole. This gives accurate control over direction of the pin. The pin is held in a stirrup by a screw and a collar (*Fig* 1225) permits the stirrup to rotate without rotating the pin a rotating pin is a common c of infection of the pin hole.

Whitchurch Howell's Pin (*Fig* 1226) is extremely satisfactory it is easy to main necessary extension by the dog-chain clips.

A CONSIDERATION OF INDIVIDUAL BONES

The treatment of *compound* fractures is dealt with in this chapter: the treatmen fractures, as such, is beyond the scope of this work and the reader is referred to on the standard works devoted to the subject. It is, however necessary to give some inst tions concerning problems such as the immobilization of individual bones involved compound fracture. As has been emphasized, a plaster-of Paris cast including the j above and the joint below the broken bone is the method of election in nearly all cases. plaster should not be provided with a window which causes œdema of the fenestrated and invites secondary infection when the wound is dressed. Plaster being porous, abs exudates seeping from the wound. A plaster-of Paris cast immobilizes a fractured l and the joints related to it more completely than can be achieved by a splint comb with traction. Nevertheless a plaster cast is not always the best method to employ given case

Absolute contra indications to the application of a plaster cast are :—

1 When there are any signs of impaired circulation in the distal part of the affe limb

2. Where there are reasons to fear that the supervention of gas-gangrene is improbable.

Tibia.—This is the commonest site for a compound fracture and compound fract of this bone lend themselves to the closed plaster method. The foot as far as the toes sh be included and the cast should extend to the upper third of the thigh In cases whe plaster cast is contra-indicated, immobilization on a Braun s splint with pin traction the calcaneus (so that the transfixion is removed as far as possible from the injured a is recommended.

Femur —Pin extension is nearly always necessary and as a general rule the u end of the tibia should be employed for this purpose Alternatively the lower end of femur is transfixed this site should only be used if there is some definite contra-indica to the foregoing Another possible alternative when the wound is small and not situ laterally or medially in the lower half of the thigh is skin traction by means of exten strapping but in this instance immobilization in a Thomas s splint is a *sine qua non*

While a hip spica plaster cast extending from the base of the toes, with the transfi pin incorporated in the plaster is the best method of immobilizing the limb, there are c formidable difficulties barring the way to its application. First and foremost, except

child it is difficult to keep the fragments in good alinement while the plaster is being applied, unless the surgeon has the advantage of an orthopædic table or comparable apparatus. Another important consideration is that a compound fracture of the femur is more likely to be accompanied by severe shock than is a compound fracture of any other bone of an extremity and the application of a hip plaster consumes a considerable amount of time. Another disadvantage of a plaster cast in this area is that in the elderly or undernourished, unless the padding is perfect, a bed-sore is liable to ensue. For these reasons a Thomas's splint with efficient skeletal or skin traction is usually the method of choice.

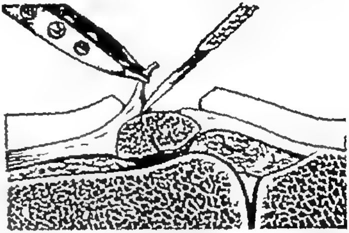


Fig. 1227.—Excision of the patella. The lateral expansion must be preserved carefully.

Patella.—When the patella is involved in a compound fracture and the bone is comminuted, or the knee-joint is opened, or the wound is severely contaminated, if the case is an early one the patella should be excised. Keeping close to the bone, the patella is cut out of the central tendon (*Fig.* 1227). The lateral expansion must be united carefully. In most cases the wound can be closed without drainage. The limb is immobilized in a plaster-of-Paris back slab.

In comparatively clean transverse fractures not involving the knee-joint, the fracture can be united with two wire or catgut sutures.

Fig. 1228. — Aeroplane splint constructed from Cramer wire and padded well. It should fit well up into the axilla. (*After L. Bader.*)

Humerus.—An efficient method of immobilizing the humerus is to construct an abduction splint (*Fig.* 1228) from Cramer wire and to pad it well. The splint is fixed to the body not with calico bandages, but with a few plaster-of-Paris bandages. If desired, plaster-of-Paris bandages can be applied over the splint and the humerus, thus combining the advantages of the lightness of the splint with the closed plaster technique.

Fig. 1229.—A thoracobrachial plaster applied; note the optimal position (45° abduction). (*After D. W. Jolly.*)

Many surgeons with experience of compound fractures of the humerus in war have found that the immobilization afforded by the aeroplane splint is insufficient and much inferior to that obtained with a thoracobrachial plaster. The difficulty of applying the latter to an unconscious patient is circumvented by using an aeroplane splint as a temporary expedient. When the patient has sufficiently recovered, usually a matter of two or three days, after a preliminary sedative and the injection of procaine solution into the brachial plexus (see p. 926), a thoracobrachial plaster (*Fig.* 1229) is applied with the patient sitting on a low stool. The surgeon sits facing the patient and the assistant sits behind the patient. A second assistant holds the arm in the desired position. The optimal position for immobilization is one of 45° abduction.

Radius and Ulna.—When an oblique fracture of the radius or ulna is difficult to control, one of the forms of internal fixation described on p. 878 is often advantageous. Compound fractures of these bones are well suited to the closed-plaster technique.

* *

In the case of an upper limb, intelligent conservatism should be the guiding principle whenever possible.

As an example of what can be achieved in this direction the following case is cited —

E. H., aged 7 was brought to hospital having been knocked down by a car The left arm was hanging by a pedicle of the brachial artery and the nerves. The pedicle had undergone axial rotation, and the casualty officer contemplated severing the pedicle there and then. Mr Trev Berrill, my house surgeon, was called into consultation, and he untwisted the pedicle and noted that the radial artery could be felt at the wrist He therefore brought the patient straight to the operating theatre The muscles and bone were covered in road dirt. What was so remarkable was the fact that there was no muscular continuity between the upper and lower segments.

Fig 1230 —Eleven years previously this patient's left arm was hanging by a pedicle consisting of blood vessels and nerves.

Fig 1231 —Radiograph three years after operation The bone-graft has been largely absorbed and remarkable regeneration has occurred.

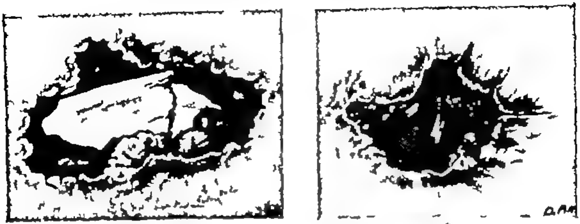
carried out débridement of the wound, and made an attempt to fashion a spike in the lower fragment and drive it into the medulla of the upper fragment. The triceps behind and the biceps and coracobrachialis in front were drawn together with sutures and the skin closed partially The limb was placed on an aeroplane splint. Considerable suppuration followed and later a sequestrum, which consisted mainly of the spike referred to, was removed. Eventually the wound healed, but there was non-union of the fracture

In due course the middle third of the fibula was removed subperiosteally and, utilizing this as a bone-graft it was driven down the medulla from above, so that the two fragments were bridged. *Fig* 1230 shows the patient eleven years later The function of the arm is unimpaired and a radiograph three years after operation showed remarkable bone regeneration (*Fig* 1231).

CHRONIC INFECTION

When the bone is the seat of chronic osteomyelitis secondary to a compound fracture Winnett Orr's method combined with antibiotic therapy is unsurpassed. The wound is excised thoroughly The diseased bone (*Fig* 1232 A) is chiselled away so as to leave a funnel-shaped cavity Bleeding is controlled by packing with dry gauze, and after hemostasis is satisfactory the wound is swabbed out with saline solution and packed with petroleum jelly gauze The cavity is packed with this material until the whole wound is filled. The remaining steps do not differ from those of the closed plaster technique for compound fracture described earlier in the chapter Discharges ooze through the plaster which often becomes malodorous, and is the main disadvantage of this method The objectionable smell is bearable if the patient can be nursed on a balcony In other circumstances putting the cast in a cellophane bag containing charcoal can be tried. Whenever feasible provided the general condition remains satisfactory and the patient is not in pain, the plaster is not removed; it can remain unchanged for upwards of eight weeks (*Fig* 1233). When

eventually it is removed in most cases the gauze will be found to have been extruded on to the surface and the wound itself will appear as a flat area of granulation tissue beneath



A B

Fig 1232.—Chronic osteomyelitis secondary to a compound fracture of the tibia. A, Condition of the wound before Winnett Orr treatment; B, Eight weeks later (*Hey Groves.*)

Fig 1233.—The limb in plaster which was not changed for eight weeks.

which the united fracture is buried. The clean wound (*Fig* 1232 B) and radiographs showing the united fracture are a joy to behold.

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CHAPTER LXXVII

ACUTE OSTEOMYELITIS

The blood-supply of a bone is derived from two principal sources —

a. The nutrient artery supplies the medulla, the endosteum, and the deep aspect of the cortex.

b. Periosteal vessels supply the periosteum and the superficial aspect of the cortex. The anastomosis between these two sets of vessels is such that if one alone is cut off the bone including the medulla, can survive. On this knowledge rest the elements of treatment. The aim is to preserve the periosteal blood-supply because the nutrient artery so often becomes thrombosed early in the disease. Effective as is the antibiotic treatment of acute osteomyelitis, circulating antibiotic is powerless to act *on the lesion* unless an adequate blood-supply to the involved bone can be maintained.

Bacteriology.—In about 90 per cent of cases the causative organism is a *Staphylococcus aureus* but in a small but increasing percentage this staphylococcus proves to be penicillin-resistant. In approximately 4 per cent the *Streptococcus hæmolyticus* is responsible. In the remainder *Staphylococcus albus Pneumococcus Salm. typhi Salm. paratyphi Salm. cholerae-suis* or *Brucella abortus* is disclosed by the bacteriologist, usually to the astonishment of the clinician.

Pathogenesis.—

a. During the period of growth the weakest part of the long bone is the diaphysial side of the epiphysial line (the metaphysis) It is here that delicate blood-vessels penetrate the epiphysial cartilage and even a slight jar is liable to rupture one or more of them, thereby causing a hæmatoma. If before the hæmatoma resolves, bacteria circulating in the blood from a distant focus settle in the clot, lively *inflammation is likely to follow* The *resulting purulent* exudate does not, as might be expected often extend along the medulla, but interosseous pressure is relieved by necrosis of bone absorption of the thinner metaphysis permitting pus to escape under the periosteum (*Fig* 1234) Thus the periosteal vessels become interrupted, and deprive the affected part of the bone of its only remaining blood-supply for as has been stated, in acute osteomyelitis, thrombosis of the nutrient artery frequently occurs, probably before the clinical signs of the disease are manifest.

Fig 1234.—Mode of formation of a subperiosteal abscess.

That portion of bone deprived of its blood-supply forms a medium in which bacterial fission proceeds apace, and by reason of its avascularity it is impossible for a circulating antibiotic to come into contact with these rapidly multiplying bacteria. Consequently if the patient survives, which with antibiotic therapy is usual, the portion of bone so affected ultimately separates from the living bone as a sequestrum

b In cases of septicæmia, as opposed to bacteræmia, acute osteomyelitis can occur in the absence of any kind of trauma by an infected embolus lodging in an artery supplying the epiphysis. In such cases occasionally osteomyelitis of more than one bone can occur almost simultaneously and the diagnosis becomes correspondingly complicated.

In cases of acute osteomyelitis that remain untreated for many days, provided the resistance of the patient is sufficiently good to withstand the blood infection, the whole diaphysis may become a sequestrum by pus under pressure stripping up the periosteum on all sides. At other times, in similar circumstances, the pus bursts through the periosteum, and depending on the location, tracks among the muscles or becomes subcutaneous.

Owing to the firm attachment of the periosteum to the epiphysis and the inherent resistance of cartilage subperiosteal pus is unlikely to invade a neighbouring joint, unless the epiphysial line is intra-articular as is the case in the head of the femur the upper end

of the humerus, the external malleolus, and the olecranon process. The most dangerous, as well as the most frequent site for concomitant purulent arthritis is the hip-joint.

DISTRIBUTION OF THE LESION

	per cent		per cent		per cent
Tibia	33	Ulna	3	Metacarpals	1
Femur	25	Metatarsals	3	Frontal bone	1
Fibula	8	Ilium	1	Maxilla	1
Humerus	8	Pubis	1	Scapula	1
Calcaneus	5	Vertebræ	1	Clavicle	1
Radius	5	Patella	1	Ribs and Sternum	1

Clinical Features.—The incidence of acute osteomyelitis has diminished during the last decade. Probably this is due to the frequency with which antibiotics are used to treat respiratory and cutaneous infections, both of which are known precursors of osteomyelitis.

Age.—Eighty per cent of the patients are between the ages of [illegible] and 17 years, the highest incidence being between the ages of 10 and 11 years. Fifteen per cent occur in adults, and 5 per cent in infants under 2 years.

Seasonal Variation.—Acute osteomyelitis has a seasonal tendency. Cases due to *Staph. aureus* are more frequent in August and September than at other times of the year.

Period of Quiescence.—For an unknown period, estimated at under 12 hours, there is no pain: pain is not experienced until the periosteum becomes involved.

Classical Signs.—Following a boil or other infected cutaneous lesion, which may have escaped the mother's notice, the child exhibits general malaise, shivering, and severe pain situated in that part of a long bone that lies near a joint. Sometimes a history of trauma, usually minor, is forthcoming. On examination the temperature is raised above 100° F (37.8° C.), (often to 102–103° F.), there is extreme tenderness over the affected metaphysis, and the nearby joint is sometimes the seat of an effusion. The intensity of the local signs varies inversely with the depth at which the inflamed bone is from the surface. Occasionally the general condition of the patient is so poor that the local signs are masked; nevertheless, unless the lesion is very deep-seated, tenderness can be elicited during a meticulous examination.

Fulminating cases with profound toxæmia, which in days gone by were common enough, especially in children dwelling in slum areas, are becoming less frequent owing to better nutrition and hygiene of the children of the working classes, as well as to early antibiotic therapy.

Summarizing. A febrile patient with pain and localized tenderness of a bone near a joint should be presumed to have acute osteomyelitis until it is proved otherwise.

Differential Diagnosis.—

1. *Acute Primary Suppurative Arthritis.*—While in this condition the maximum tenderness is over the joint—not close to it—it is sometimes extremely difficult to differentiate acute primary infected arthritis from osteomyelitis with secondary invasion of the joint.

A presumptive diagnosis of primary infected arthritis can be made when the pain and swelling is limited to the joint, and there is almost complete limitation of movement of the joint in question. The diagnosis may seem substantiated by aspiration of purulent fluid, and positive culture. However, too often it subsequently transpires that radiography shows typical changes of osteomyelitis in the metaphysial area of the bone. Pathological fracture is not an uncommon sequel in such cases if weight bearing without a plaster cast is permitted. If doubt exists as to whether there is a primary lesion in the bone, it is far better to perform an exploratory operation.

2. *Rheumatic Fever.*—Although the pain of rheumatic fever usually flits from joint to joint, in a few cases it remains stationary in one joint. The cases that are especially difficult to differentiate from rheumatic fever are the ones when the patient has septicæmia, and more than one metaphysis is attacked. Aspiration of the joint in rheumatic fever yields a turbid fluid which has a high cell-count but will produce no growth on culture. There may be no detectable cardiac changes, but if acute rheumatism cannot be ruled out, electrocardiography is advisable.

3. *Tuberculous Osteitis* can closely resemble mild acute osteomyelitis. By the time the patient is brought for advice X-ray changes in the bone are likely to be obvious and a radiograph of the thorax may reveal a pulmonary lesion. Excision and biopsy of an enlarged regional lymph-node sometimes shows tuberculous inflammation, while a Mantoux or a Heaf's reaction is likely to be positive if the lesion is tuberculous.

4. *Syphilitic Periostitis.*—The commonest site is the anterior aspect of the upper third of the tibia, where visible and palpable swelling will be found. In contrast to acute osteomyelitis, radiographic changes will be evident at the time of the clinical onset of the disease.

5. *Acute Anterior Poliomyelitis.*—The overall picture is rather similar—an ill child with pain and loss of function of a limb. In anterior poliomyelitis the pain and tenderness is spread throughout the main muscular mass, whereas in osteomyelitis the tenderness is greatest on direct pressure or percussion of the bone.

6. *Malignant Neoplasm.*—This is often the greatest problem of all, for sarcoma and osteomyelitis can remain indistinguishable for a considerable time. In both conditions, if one waits long enough, there are destructive changes of the bone detected by radiography. Often the only certain proof of the diagnosis is an incision (which reveals an absence of pus) and biopsy.

Radiography shows no abnormality in early acute osteomyelitis. None the less, radiographs should be taken when the patient is first seen, for negative radiographs are valuable in assessing subsequent changes. In acute osteomyelitis correctly treated, the first radiographic changes are seen in approximately 21 days. The exception to the rule is in neonatal infections where radiographic changes occur rapidly (*see* p. 894).

Pathological Investigations.—

Blood Culture.—A specimen for blood culture should be taken before antibiotic therapy is commenced. The fact that some patients have been given antibiotic therapy already swells the number of negative cultures to about 60 per cent. In all cases a request is made for testing the sensitivity of the organism, if present, to antibiotics. If the blood culture is positive it should be repeated on alternate days, until negative. Usually as a result of antibiotic therapy this is attained in three days.

Leucocyte Count is usually raised, but shows such great variations that it is of little diagnostic assistance at the time it is required (J. Trueta).

Erythrocyte Count.—While often normal in the early stages of the disease, in severe cases it becomes reduced by the end of the first week. It should therefore be repeated in cases of septicæmia, for when reduced, blood-transfusion is beneficial.

Erythrocytic Sedimentation Rate.—This is elevated almost constantly in acute osteomyelitis, and serial tests are of signal value in estimating the progress of the case.

Sensitivity to Antibiotics (usually three days is required for the result).—If the organism is found to be a penicillin-resistant staphylococcus, or another penicillin-resistant organism, the antibiotic will, of course, be changed from penicillin to one to which the organism has been found to be sensitive.

TREATMENT

On Admission.—The patient is examined by the surgeon in charge of the case, and the site and the extent of the tenderness is noted with extreme care. At least 10 ml. of blood are removed by venepuncture for (*a*) culture; (*b*) erythrocyte count; (*c*) leucocyte count; (*d*) sedimentation rate test. The affected part is immobilised with a splint that will permit re-examination without disturbing the patient.

Immobilisation.—During the phase of acute inflammation perfect immobilisation is required. For each limb, and for every joint, there is a position of optimum rest, viz.:—

POSITIONS OF OPTIMUM REST

JOINT	POSITION	JOINT	POSITION
Shoulder	Abduction 45°; flexion 30°; external rotation 15°	Hip	No abduction or adduction; rotation nil; flexion 20°
Elbow	Extended to about 100°	Knee	Flexion 15°
Forearm	Mid prone-supine position	Ankle	Right angle or, in woman, a degree or so below
Wrist	Extension 15–20°		
Digits	All joints flexed about 25°. Thumb abducted and opposed moderately	Tarsal	Neutral as to inversion or eversion
		Toes	Maintain flexion of metatarsophalangeal joints and extension of interphalangeal joints
Spine	Normal curves maintained		

(N. Capener)

The splintage recommended at this stage is :—

For the tibia and fibula, or calcaneus a padded splint with foot piece the splint should extend above the knee-joint.

For the bones of the forearm a padded splint extending from the palm to the upper third of the upper arm is adequate

For the femur and for the humerus a Thomas s splint with moderate extension by means of an adhesive plaster stirrup cannot be bettered.

There is no contra-indication to the use of plaster-of Paris splints provided they are split to enable examination of the limb In many instances these are preferable, because of the better immobilization they afford.

If feasible, the part is elevated.

Antibiotic Therapy.—Penicillin treatment, 500 000 units 12-hourly is commenced. In view of the increasing incidence of penicillin resistant organisms, it is expedient to administer a second antibiotic (streptomycin, aureomycin or erythromycin) until the sensitivity of the organism becomes known ; usually this takes three days.

Restoration of Fluid Balance.—A high fluid intake must be assured. The aim is to ensure a moist mouth and skin, and an adequate output of urine of normal specific gravity and free from urates. If the general condition is good, the patient is encouraged to drink barley water and water flavoured with fruit juice in toxic patients continuous intravenous dextrose-saline solution is administered slowly A pint (475 ml.) of plasma given early during the first 24 hours is recommended as part of the fluid intake Blood transfusion is indicated only if the blood examination shows a low hæmoglobin content or low red cell count.

Sedation.—Barbiturates are valuable for controlling anxiety Pain is alleviated by morphine gr $\frac{1}{6}$ (10 mg) repeated if necessary in 6 hours, if the patient is a youth or an adult, while in children nepenthe, 1 minim for each year of age is the narcotic of choice.

At the End of 24 hours.—The same surgeon re-examines the patient noting particularly the 4-hourly temperature chart the pulse-rate, and the result of the blood examination, in so far as the results are available. He then examines the tender area,[1] and unless the tenderness has decreased considerably in both extent and intensity from that of the previous examination (allowance being made for any narcotic that has been administered within 6 hours) the patient is prepared for operation under general anæsthesia.

Operation.—Wherever possible the use of a pneumatic tourniquet is advised. An incision is made over the area of maximum tenderness. The method of exposing each of the more commonly affected sites is described on p 890 The periosteum is divided and the subperiosteal abscess is evacuated by suction, or mopped with dry swabs, not forgetting to collect a specimen of pus for bacteriological investigation.

Metaphyseal Decompression.—To relieve the intramedullary tension three to four drill-holes through the cortex are made in the following way The drills (three should be available) should be approximately $\frac{3}{16}$ in. (4·5 mm.) in diameter If pus is encountered, the drill should be changed before another hole is made. If pus wells from the first drill hole, which is made just below the metaphysis, a second drill-hole is made about $\frac{1}{2}$ in. (1·3 cm.) lower this is repeated until a site is reached where blood and not pus is encountered (*Fig* 1285). If blood exudes from both the first and the second drill holes, it is unlikely that pus will be located at a greater distance from the metaphysis. The tourniquet is then removed, bleeding vessels are ligated, and oozing points in the soft tissues are coagulated with a diathermy skin only is sutured without drainage Drainage is not only unnecessary but may be harmful by permitting secondary infection. The limb is then re-immobilized.

After Treatment.—Penicillin treatment[2] is continued for three weeks, unless the organism is penicillin-resistant, in which case the most suitable antibiotic as revealed by sensitivity tests, is given for a like period. Five days later the wound is re-examined in the operating theatre, and a hæmatoma, if present, is aspirated. The stitches are removed on the tenth day and unless there is some contra indication, a complete plaster cast is applied. The

[1] In under 10 per cent of cases do the symptoms abate sufficiently to justify continuing with non-operative treatment. In a proportion of these cases recurrence of tenderness occurs ; it is therefore necessary to examine the patient twice a day for at least three further days.

[2] The return of the E.S.R. to a normal level is a useful indication as to when to conclude penicillin therapy

cast is necessary because if, as is hoped, the operation succeeds in preventing involucrum formation, the bone is liable to fracture when weight bearing is permitted.

The first positive radiograph is usually obtained about three weeks after the onset of the disease. Radiographic examinations are made at intervals, and on the findings it is judged when it is safe to discard the plaster cast.

By combining antibiotic therapy and early conservative operation, Professor Trueta has been enabled to report a series of 150 cases without mortality, without joint involvement,

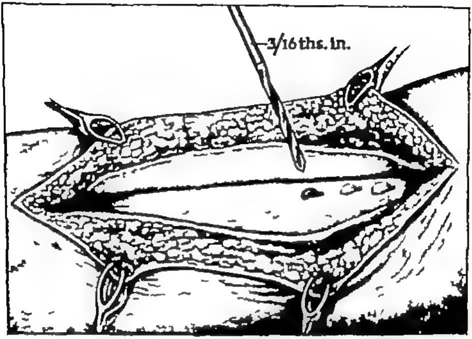

Fig. 1225.—Pus has been evacuated from beneath the periosteum. In this case deep pus is revealed by the first and second drill-holes, but blood only is exuding from the third drill-hole (i.e. the one farthest away from the metaphysis). (*After J. Trueta.*)

and with sequestrum formation in only 17. Twelve of the latter, though classified as sequestra, were merely *periosteal fragments of dead bone* that were removed easily.

Many cases treated by penicillin therapy and evacuation of pus without drilling the bone after a certain period of quiescence show a recurrence of infection (Chigot and Polony).

METHODS OF DISPLAYING INDIVIDUAL BONES

Femur.—

Upper End.—The incision, about 8 in. long (20 cm.) commences above the upper third of the greater trochanter and passes vertically down the lateral aspect of the thigh. The tensor fasciæ latæ is divided in the length of the incision. The plane of cleavage between

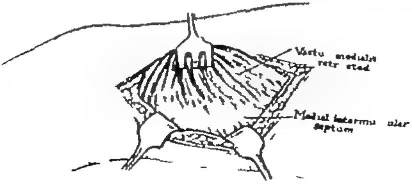

Fig. 1226.—Exposing the lower end of the femur from the medial aspect. (*After Banks and Laufman.*)

the rectus femoris and the vastus lateralis is found, and very few muscle-fibres need be cut to separate these two muscles and expose the bone.

The first drill hole is made over the greater trochanter and should be directed towards the head of the femur. After it has been made if no pus exudes it is advisable to pass a probe through the cancellous bone towards the head. In one instance an appreciable amount of pus was evacuated by this expedient.

Lower End.—

Medial approach. The medial condyle is located and an incision passes straight upwards for 5 in. (12.5 cm.). The deep fascia is incised to expose the vastus medialis muscle. The medial edge of this muscle is freed by sharp dissection from the intermuscular septum. (*Fig.* 1236). The muscle can then be retracted laterally, exposing the periosteum. This exposure is simple and safe.

Lateral approach. A vertical incision is made immediately *in front of the tendon of the biceps.* Care must be taken not to open the suprapatellar pouch, which communicates with the knee-joint.

Tibia.—

Upper End.—An incision over the middle of the subcutaneous portion of the bone must be avoided rigorously, for it invites an adherent scar that is liable to interfere with the revascularization of the bone. A curved incision that slightly overlaps the crest of the tibia (*Fig.* 1237) affords ample exposure, and leaves a scar that cannot become adherent to the bone.

Lower End.—A similar incision is made overlapping the crest of the tibia.

Fibula.—The upper part or the lower part of the bone, as the case may be, is exposed through a lateral incision with retraction of the peronei anteriorly. One must be careful to preserve the integrity of the external popliteal nerve as it winds around the neck of the fibula when exposing the uppermost part of the bone.

Tarsal Bones.—With the exception of the os calcis, it is usually impossible to be sure which bone is affected. Guided by local tenderness, a dorsal incision is made pursuing a course between the extensor tendons; this gives the best approach.

Os Calcis.—The os calcis, on the other hand, can be exposed readily through a medial or lateral incision, as the site of maximum tenderness dictates.

Clavicle.—The clavicle is displayed easily by an incision along *its subcutaneous border.*

The Scapula.—Make an incision over the spinous process, enlarging it downwards or upwards by an extension following the vertebral border if necessary. In two cases where this bone was affected, pus was discovered under the periosteum in the infraspinous fossa.

Fig. 1237.—Incision for exposing the upper part of the tibia.

Humerus.—It is necessary to bear in mind the relationships of the radial nerve and preserve this nerve at all costs. Whichever part of the bone is to be exposed, the skin incision follows *the line between the tip of the* coracoid process to the middle of the fold of the elbow. The patient lies with his arm by his side, supported by the operating table.

Upper End.—The incision commences at the tip of the coracoid process and extends downwards between the pectoralis major and the deltoid muscle for a distance of 5 in. (12.5 cm.). Much of the upper half of the shaft can be displayed by retracting these muscles. If the head of the humerus is to be uncovered, retraction of the deltoid is insufficient. A thin slice off the clavicle, removed with a hammer and chisel, will detach the origin of the deltoid and give full exposure (*Fig.* 1238 B).

Lower End.—The incision is made along a line connecting the middle of the antecubital fossa with the coracoid process. It need only be 4 in. (10 cm.) long. Divide the deep fascia in the line of the incision. Identify the outer edge of the biceps. Split the brachialis longitudinally a finger-breadth from the outer edge of the biceps (*Fig.* 1238 A). *Instruct the assistant to flex the elbow* and the humerus is readily accessible. The radial nerve is not seen.

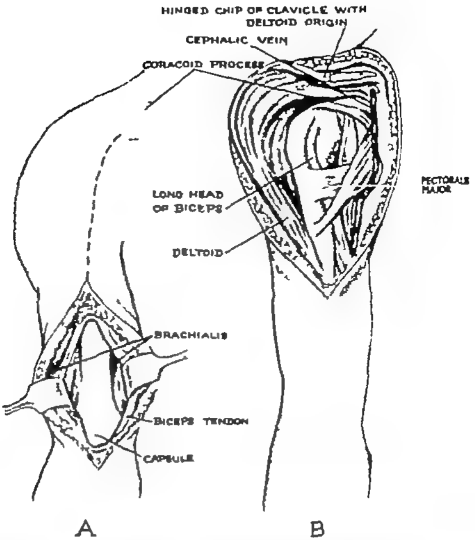

Fig 1228.—A, Incision for exposing the lower end of the humerus by splitting the brachialis in the manner described. B Incision for exposing the upper end. The head of the bone has been uncovered by removing a thin slice off the clavicle, from which the deltoid arises.

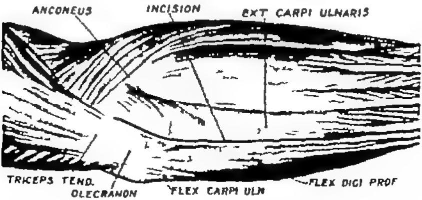

Fig 1229 —Exposure of the upper end of the radius. Showing the line of the skin incision and the plane through which the ulna is reached (*After H B Boyd*)

Radius.—

The Upper End of the radius, on account of its thick muscular clothing is comparatively inaccessible. This, however is a minor difficulty It is the possibility of injuring the posterior interosseus (deep branch of the radial) nerve which is the bugbear of the operation. H. B. Boyd explains that this nerve enters the forearm between the superficial and deep planes of the supinator muscle and if the supinator is detached from its origin and elevated from the bone the nerve is protected. The incision commences 1 in. above the tip of the olecranon on the lateral side of the triceps. It passes downwards, as shown in *Fig* 1239 for about

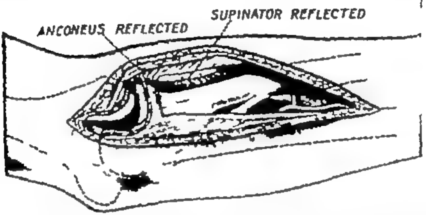

Fig 1240.—The supinator having been detached from the ulna and swept aside both the radio-humeral articulation and the upper part of the radius are displayed. If further room is necessary the dorsal interosseous artery must be divided between ligatures. (*After H B. Boyd.*)

7 in. (17 5 cm.). The incision is deepened on to the dorsal surface of the ulna and the muscles are elevated subperiosteally—a process which can be accomplished with ease. The supinator can now be identified and its deep fibres are divided as close as possible to the ulna. This muscle can now be peeled off the radius and when the muscles on each

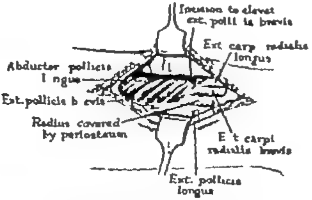

Fig 1241.—Exposure of the distal fourth of the radius. (*After Banks and Laufman.*)

side are retracted, the radio-humeral articulation, the head of the radius, and the upper third of the shaft of the radius are in view (*Fig* 1240). If further exposure of the radius is desired, the dorsal interosseous artery must be ligated and the muscular flaps reflected from farther down the bone

The Lower End of the bone is the part usually diseased. To expose the lower end, a vertical incision is made over the dorsal aspect of the middle of the radius, commencing at the level of the wrist joint and extending upwards for about 4 in. (10 cm.). The skin flaps are undermined, and the deep fascia is incised, displaying the bellies of the abductor pollicis

longus and *extensor pollicis brevis* wrapped over the *extensores carpi radialis longus* and *brevis*. The incision is made through the fascia, as shown in *Fig* 1241 After the bellies of the former muscles are separated from the latter tendons, the bellies are retracted upwards. This, combined with retraction of the tendons laterally gives good access to the lower third of the radius.

Ulna.—The ulna like the tibia, has a subcutaneous surface throughout its length. Consequently it is technically a simple bone to display

Carpal Bones.—These are approached through a dorsal incision, and the extensor tendons are retracted suitably

Frontal Bone.—(*See* p. 1072.)

SPECIAL FORMS OF ACUTE OSTEOMYELITIS

Acute Osteomyelitis in Early Infancy runs a rapid course. Too often the correct diagnosis is made late, after irreparable damage to the epiphysis and the neighbouring joint has occurred The upper end of the femur is the bone most often attacked, and the hip-joint then becomes infected early A normal temperature and the absence of a general reaction are often misleading the infant shows so little systemic disturbance in spite of advanced local disease that over and over again the diagnosis of acute osteomyelitis is not entertained. The disease should be suspected if the infant is irritable and there is swelling and loss of function of an extremity these are the outstanding symptoms, which are often confused with those of scurvy (D W Blanche).

The phalanges are not uncommonly affected whereas in older children this is rare

There is one facet which simplifies the diagnosis of acute osteomyelitis in the newborn. Radiographic changes occur rapidly and are usually evident by the time surgical advice is sought.

Acute osteomyelitis in the newborn appears to be on the increase. In no less than 80 per cent of cases the causal organism is a penicillin resistant staphylococcus.

Treatment —While the administration of chlortetracycline (aureomycin) controls the toxæmia, the exhibition of this drug or other broad-spectra antibiotics, in the newborn infant is liable to be followed by staphylococcal enterocolitis. On this account achromycin is recommended in these cases, but whatever antibiotic is employed it should be discontinued as soon as the blood infection is controlled. Early operation is imperative In cases of acute osteomyelitis affecting the upper end of the femur splinting is important ; full extension and abduction should be applied

Fig 1242.—Scars resulting from not draining acute osteomyelitis of the maxilla early into the mouth.

Acute Osteomyelitis of the Maxilla in Sucklings and Infants is an infection probably arising from a tooth follicle *The infection may proceed from the mother's breast an attendant's fingers, or a feeding bottle* and the highest incidence is during the third week of life Infection of the maxillary antrum, if it occurs, is secondary The condition is essentially an acute *inflammation of the maxilla* with thrombosis of its nutrient vessels, followed ultimately by sequestration of necrotic bone and tooth follicles. Rarely does early antibiotic therapy prevent sequestration.

The first sign is the appearance of redness and swelling below the inner canthus. At this time the differential diagnosis between dacrocystitis and orbital cellulitis is difficult Radiological investigation is of no value at this stage The inflammation progresses until it reaches the alveolar margin. Before the infection has advanced so far no time should be lost in incising the mucous membrane and the periosteum into the mouth using an incision in no way differing from that of the Caldwell Luc operation (see p 1074) this will prevent visible scarring (*Fig* 1242).

The second stage consists of multiple discharging sinuses into the mouth or if not drained therein on the cheek. This stage persists until sequestra are extruded or removed by operation. The final sequestrum is usually from the inferior orbital margin. In a number

of cases the causative organism is a penicillin resistant *Staph. aureus*. Consequently treatment by a penicillin-streptomycin preparation, as advocated for osteomyelitis in the new born, is also strongly recommended in this instance.

While the superior maxilla is most frequently attacked, the disease occurs occasionally in the mandible.

Acute Osteomyelitis of the Maxilla in Children and Adults.—The blood supply of this bone is derived almost entirely from the internal maxillary artery the branches of which form anastomosing loops. As a consequence, sequestra can form within one or more of these arterial arcades. However if the internal maxillary artery itself becomes thrombosed the entire upper jaw sequestrates, and bony regeneration is almost entirely absent. By vigorous treatment with antibiotics very early in the disease, sometimes operation can be avoided entirely for resolution without sequestrum formation occurs. More usually a comparatively early incision above the alveolar margin through the periosteum is imperative If left untreated, septicæmia, cavernous sinus thrombosis, or other intracranial complications are liable to ensue.

Osteomyelitis can occur from an extension of an alveolar abscess (*see* p 829) in either the maxilla or the mandible.

Typhoid Osteomyelitis occurs nearer the centre of a long bone than the usual place (the metaphysis). Other bones frequently affected are the sternum and the ribs.

Paratyphoid Osteomyelitis attacks the lumbar spine in about 70 per cent of cases (R. Rozansky et al.)

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I have to thank Mr Dennis Walker for many valuable suggestions connected with the revision of this chapter

CHAPTER LXVIII

JOINTS

SPRAINS

The function of a ligament associated with a joint is to check excessive movement of that joint until the appropriate muscles come into action. A joint ligament is torn only when the violence is so sudden that the muscles cannot contract until it is too late to spare the ligament

A sprain is a *partial* tear of a joint ligament. It is diagnosed by the complaint of pain, local swelling, and the elicitation of tenderness in the line of the ligament; sometimes bruising appears. X ray examination to exclude bony damage is a wise precaution.

The commonest site for a sprain is the external lateral ligament of the ankle-joint. Lesions of this ligament will be described and when necessary the principles involved can be applied to other joints. First of all it is highly important to determine that the injury *is* a sprain, and not a complete tear of the ligament. In the case of the external lateral ligament of the ankle-joint a complete tear always takes the form of avulsion of the ligament from its attachment to the fibula. In every relevant case the following test should be carried out otherwise an avulsion of the lateral ligament is liable to be overlooked. The ankle is passively inverted a manipulation which, if carried out slowly does not cause much pain. If the ligament is avulsed tilting of the talus will become evident on the anterolateral aspect of the joint. In doubtful cases this finding can be confirmed or disproved by an X-ray examination while the surgeon holds the ankle in full inversion (Sir Reginald Watson-Jones). Avulsion of this ligament should not be classified as a sprain it is treated as a fracture—indeed it is sometimes associated with a chip fracture of the external malleolus.

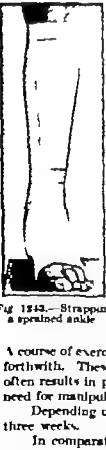


Fig 1243.—Strapping a sprained ankle

Treatment of a sprain depends upon the severity of the soft tissue damage as assessed by a clinical examination

Severe Cases—If gross swelling and bruising are present the limb should be elevated and a crêpe bandage applied firmly from the toes to the knee the bandage is removed twice a day for massage. When the swelling has subsided a toe-to-knee plaster cast is applied, in which the patient is encouraged to walk. After three weeks the cast is removed, and a course of remedial exercises is given.

Less Severe Cases—A toe-to-knee (including the heel) flexible adhesive bandage is applied supplemented by zinc oxide adhesive strapping bands as shown in *Fig* 1243; this support is retained for two weeks. The bands relieve the lateral ligaments of strain, and contribute greatly to the relief of pain. Weight bearing is insisted upon from the commencement of this treatment, and the patient must be instructed to walk correctly: the surgeon is responsible for seeing that he does so, for a limp is liable to become a habit very difficult to eradicate. A course of exercises designed to use every muscle that activates the joint is embarked upon forthwith. These measures will prevent or reduce œdema which if allowed to persist, so often results in periarticular adhesions. If this treatment is adopted there is very seldom need for manipulation of the joint under an anæsthetic.

Depending upon the severity of the injury the bandages are dispensed with in two to three weeks.

In comparatively minor ligamentous tears the infiltration of 1 per cent procaine has been advocated so that activity can be resumed at once Unfortunately after 24 hours the pain often recurs with increased severity and withal the practice is dangerous, for the pain is a warning that damage has been done and that further activity will result in increase of the injury (P Lewin).

JOINT EFFUSIONS

An excess of fluid in a joint demands urgent treatment on diagnostic and therapeutic grounds. It is only by aspiration that a certain knowledge is obtained of the nature of the effusion and, as it is not uncommon for effusions to be temporary if aspiration is not carried out when the opportunity presents, a cardinal diagnostic aid is thrown away The presence of an excess of fluid in a joint is harmful because it stretches the ligaments and if stretching is permitted to continue for even a few days, laxity of the ligaments will persist for a long time. Furthermore, if the effusion is of blood an irritative reaction of the joint occurs this is followed by synovial thickening which frequently gives rise to prolonged and even permanent stiffness of the joint. Trauma to a joint frequently causes an effusion of blood or synovial fluid in excess, depending upon the degree of violence. In cases of a fracture involving a joint, frequently the fluid aspirated contains globules of fat which can be seen floating on the blood if it is placed in a shallow dish A hæmarthrosis in the absence of trauma suggests general disease such as purpura or hæmophilia, and calls for scrutiny of the skin for purpuric spots and special laboratory examination of the blood (see p 68) On the other hand an excess of synovial fluid without trauma is particularly suggestive of tuberculous infection, and in such cases the pathologist should be asked to culture the specimen for tubercle bacilli, or perform a guinea pig test.

Seropurulent or frankly purulent effusions occur in suppurative arthritis (see p. 904) and if pus is aspirated the diagnosis cannot be in doubt.

Aspiration of a Joint should always be carried out in the operating theatre with full aseptic precautions after preparation of the skin as for arthrotomy Local anæsthesia is satisfactory in all cases except the hip-joint. It is possible to aspirate the hip-joint under local anæsthesia, but it is easier under general anæsthesia because of the depth of the joint from the surface and the consequent extensive area that requires infiltration. In all instances it is essential to render every layer of tissue, from the skin down to and including the synovial membrane, insensitive. Failure to do this may result in sudden muscular contraction as a result of pain with, possibly fracture of the needle deep in the tissues, or even in the joint. To minimize this accident, after raising the preliminary intradermal weal a large-bore intramuscular needle should be employed for the infiltration and a proper aspirating needle for the actual entry into the joint.

When introducing a hollow needle into a joint it will be found to be satisfactory to rely on a hollow needle alone, rather than a needle connected to an aspirating syringe. The needle by itself can be manipulated with greater delicacy When the joint has been entered the intra-articular pressure is usually sufficient to force the fluid through the stem of the needle (sometimes it takes a moment for thick pus to well up) When satisfactory entry is assured the aspirating syringe is connected with the needle.

After the aspiration the needle puncture is sealed with mastisol or collodion on a pledget of wool.

TECHNIQUE OF ASPIRATING VARIOUS JOINTS

(*Fig* 1244)

Wrist joint.—The radial styloid is palpated—this gives the line of the joint. The needle is entered between the tendons of the extensor pollicis longus and the extensor indicis, which are felt readily The needle is directed forwards in an ulnar direction, and 45° in a proximal direction

Elbow joint.—Flex the elbow to a right angle. Ascertain the position of the head of the radius. Insert the needle from the posterolateral aspect above the head of the radius, which serves as a guide Alternatively when the joint is much distended it can be entered on either side of the olecranon.

Shoulder joint.—The coracoid process is palpated readily in the delto-pectoral interval below the clavicle. The needle is entered ½ in. (12 mm.) below and ½ in. medial to the tip of the coracoid, and directed backwards with a lateral inclination of 30° It will then enter the inferior part of the shoulder joint, where there is a loose pouch of synovia and capsule

Ankle-joint.—The line of the joint is ascertained by palpation and when possible, by movement of the foot on the tibia. Choosing a point on this line just medial to the lateral malleolus, the needle is directed backwards and slightly downwards, so as to strike the interval between the tibia and the talus.

TECHNIQUE OF ASPIRATING VARIOUS JOINTS

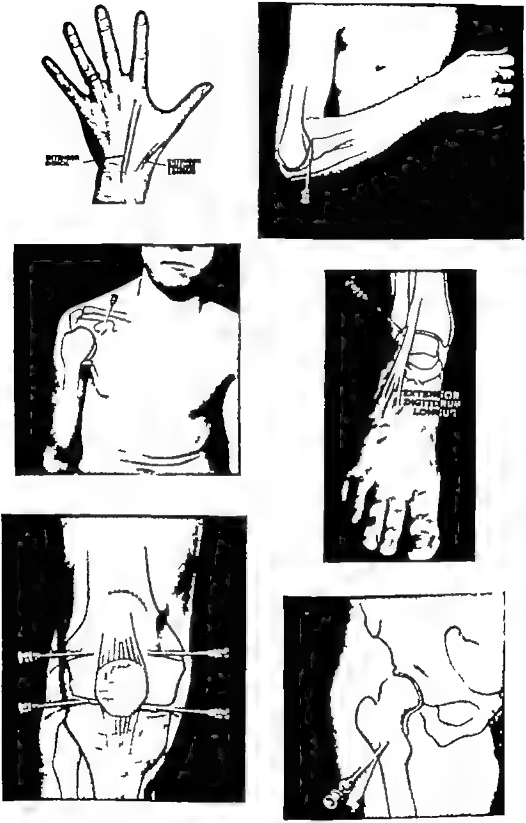


Fig. 1244.—Optimum site of puncture for aspirating certain joints.

Knee-joint.—When as is frequently the case the effusion into the suprapatellar pouch is evident, the needle can be introduced just medial or just lateral to the upper border of the patella. Entry into the suprapatellar pouch is easy and safe. The alternative route, directing the needle into the joint on one or other side of the lower pole of the patella, is more difficult and is capable of causing damage to the articular cartilage.

Hip-joint.—The hip-joint is the most difficult joint into which to insert a needle. A lumbar puncture needle is the best type of needle to employ Palpate the greater trochanter and refer to the anteroposterior radiograph in order to ascertain the line of the neck of the femur The needle is inserted into the anterolateral aspect of the thigh opposite the lower edge of the base of the neck of the femur The needle is directed inwards, slightly upwards, and parallel with the lower aspect of the femoral neck. It may be necessary to manipulate the point of the needle several times before a satisfactory entry is assured.

Alternative Method—The femoral artery is palpated 1 in. (2 5 cm.) below the inguinal ligament and the needle is inserted directly backwards lateral to the artery When the femoral artery is impalpable, a point 1 in. below and 1 in. lateral to the mid-inguinal point is chosen. The needle is pushed through the capsule into the cartilage of the femoral head. To prove that this is the case, the thigh should be rotated externally slightly whereupon the hilt of the needle will move medially Very slight withdrawal of the needle, to allow the bevel to emerge from the cartilage, will permit aspiration or injection of fluid into the joint

DISLOCATIONS

For a dislocation to occur considerable violence is required the capsule and at least one of the ligaments of the joint must be torn before the articular surfaces can come apart. If this extensive damage is borne in mind, the folly of allowing free movement after reduction is apparent. A period of rest for the joint is essential to allow these torn structures to heal and to unite at the correct tension.

At the time of the first examination, a careful search must be made for an associated fracture a nerve injury or a vascular lesion. Their absence must be recorded, and the presence of one or more of them not only be recorded, but also should be brought to the patient's notice at once Failure to heed this injunction may result in the surgeon being held responsible for the occurrence of one or other of these complications, which it is alleged occurred at the time of the reduction of the dislocation.

When facilities are available the diagnosis should be checked radiologically but when this diagnostic aid can be obtained only after considerable delay the dislocation should be reduced and X ray confirmation of reduction sought afterwards. This advice is based firstly on the fact that the injury is a very painful one and secondly on the belief that the sooner the soft parts are returned to their proper position the more rapid and complete is the return of function. If pre-operative X rays are dispensed with, the reason for this step must be explained to the patient

After reduction a further examination is made to determine the presence or absence of any nervous or vascular lesion, and these findings are again recorded.

Anæsthesia is not always necessary particularly in the case of the shoulder When anæsthesia is employed, it should be preceded by appropriate premedication, and carried out as though a major surgical procedure was contemplated, with due regard to the time of the last meal. The whiff of gas and kindred light anæsthetics are dangerous. Either full anæsthesia or none at all must be insisted upon.

SHOULDER JOINT

Anterior Dislocation.—Usually anæsthesia is not required. If properly employed Kocher's method of reduction is excellent It depends upon tiring out the contracted subscapularis until that muscle relaxes and permits the other muscles which activate the shoulder joint to reduce the dislocation. The patient lies on a couch, and he is told that no violent manipulation is contemplated. By talking to him sympathetically a considerable degree of relaxation is obtained. This relieves pain, and allows further relaxation. The elbow on the affected side is then grasped and gentle strong and steady traction is applied in the axis of the humerus (*Fig* 1240 A). This brings the head of the humerus down to or below the level of the glenoid. With his other hand the surgeon grasps the wrist of

the affected limb, and very slowly rotates the arm externally (*Fig* 1240 B) This movement must be performed very slowly and gently and must not evoke the slightest wince from the patient It may take five minutes. Usually as the limit of external rotation is reached the head of the humerus glides into position, and such should be the surgeon's control that the patient is unaware of the precise moment of reduction. If reduction does not occur at this stage of the manipulation, the elbow is carried towards the patient's umbilicus and the humerus is rotated internally by placing the patient's hand on his opposite shoulder (*Fig* 1240 C); this additional manœuvre frequently accomplishes reduction.

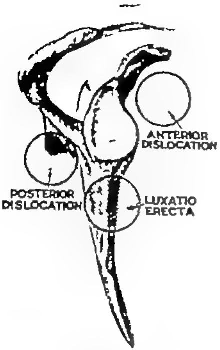
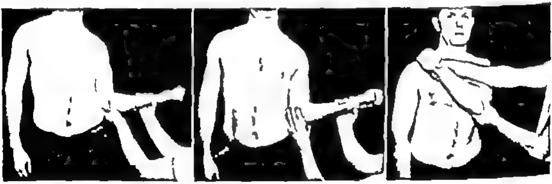


Fig 1245 —Dislocation of the shoulder joint.

The Method of Hippocrates —If Kocher's manœuvre fails to reduce the dislocation at the first attempt, and the dislocation is recent, the following method is bound to succeed With the patient lying on his back, the surgeon removes his own right shoe for the right shoulder and his left shoe for the left shoulder He then grasps the wrist with both hands, and places his stockinged foot against the ribs close to the axilla The patient's arm is carried slightly inwards, so that the surgeon's foot abuts the head of the humerus, which is levered outwards, and is thus guided into the glenoid fossa. While traction and leverage are being maintained the limb is rotated externally Performed as here described, nerve or arterial injury cannot occur

Complications of a Dislocated Shoulder Joint.—Regarding nerve injuries, these are much more likely to occur as a result of the dislocation than from skilful manipulations to reduce the dislocation. Before reduction is attempted, 7 per cent of patients with a dislocated shoulder have a nerve lesion, usually of the circumflex nerve. By laying one hand upon the deltoid and asking the patient to attempt abduction against the resistance of the surgeon's other hand placed over the patient's elbow the integrity of the deltoid can be tested without the patient moving his arm.



A B C

Fig 1246.—Kocher's method for reduction of a dislocated shoulder (*M F P Fitzgerald.*)

When reducing a dislocated shoulder the utmost gentleness is essential, for it is possible to fracture the shaft of the humerus by rotation in Kocher's method.

The late George Stephen encountered a case where an arteriosclerotic artery was torn during reduction of a dislocated shoulder

After reduction the integrity of the supraspinatus tendon is demonstrated by asking the patient to abduct his arm about 45° Having demonstrated the integrity of this muscle *a collar-and-cuff sling is applied, a sheet of wool placed between the arm and the trunk,*

and the limb bound to the side for three weeks. The hand and wrist are exercised frequently but the limb must not be rotated externally. At the end of this period active exercises are employed until full movements of the shoulder joint are regained.

If the complication of ruptured supraspinatus tendon is recognized immediately and the limb is immobilized in an abducted, externally rotated position on a frame, recovery is usually secured without operation.

Posterior Dislocation is uncommon, easily overlooked, and is prone to occur in elderly persons. One sign which helps in diagnosis is unusual prominence of the coracoid. In this injury the posterior part of the capsule is torn. Reduction is carried out by traction and external rotation (as in Kocher's method), but after reduction the limb must be immobilized for three weeks in a plaster spica with 45° abduction and full external rotation at the shoulder.

Luxatio Erecta.—This very rare injury is reduced by upward traction on the limb which is afterwards immobilized in a collar-and-cuff sling as for an anterior dislocation.

Fig 1247.—Arm in a collar-and cuff sling. This is made of green flannel bandage and is sewn closely around the wrist, so that the hand cannot slip out.

ELBOW JOINT

The common dislocation consists in a backward displacement of the forearm bones, and may be accompanied by avulsion of the medial epicondyle with lesions of either or of both the median and ulnar nerves. Obstruction of the brachial artery may also occur. Whether one or more of these complications is present must be ascertained before reduction of the dislocation. An anæsthetic is required and gentle, sustained traction is applied to the forearm in the position in which it lies. As the forearm bones are frequently displaced laterally as well as backwards, local pressure is applied in a medial direction. The dislocation is reduced without difficulty. Post-operative radiographs should be taken to confirm reduction and to show the position of the medial epicondyle. This has its own centre of ossification which appears at the age of 7 years and fuses with the humeral shaft at the age of 17 years. Between these ages the medial epicondyle may be avulsed, and during reduction it is possible for the detached epicondyle to become entrapped within the joint from whence it can be withdrawn often only by operative means. Special regard should be paid to the radiograph to be sure that the medial epicondyle lies in its correct anatomical position. A collar-and-cuff sling is then applied (*Fig* 1247) and retained for three weeks, after which movement is regained by active exercises. Myositis ossificans need not be feared in recent dislocations if a three weeks' period of rest in a collar-and-cuff sling is insisted upon.

METACARPO-PHALANGEAL JOINT OF THE THUMB

Gently hyper-extend the thumb and push the base of the proximal phalanx over the head of the metacarpal. After reduction a plaster cast is applied to immobilize the joint for three weeks. On rare occasions reduction is impossible because of interposition of a portion of the capsule or the short thumb muscles. Open reduction is then necessary.

HIP JOINT
(*Fig* 1248)

Lay the fully anæsthetized patient on blankets on the floor and instruct an assistant to fix the pelvis by downward pressure of both anterior superior iliac spines. Grasp the affected limb and lift it by the knee so that the long axis of the femur points towards the ceiling. Flex the knee to a right angle and correct any rotational deformity present. Then with the fingers interlocked beneath the lower half of the popliteal space, apply upward traction on the thigh (*Fig* 1249): the essence of reduction lies in the vertical lifting of

the femur. It should be noted that this method applies equally to anterior and posterior dislocations, for flexing the thigh and placing it in neutral rotation results in the head of the femur passing to the postero-inferior aspect of the acetabulum. A forward thrust is then all that is required to effect reduction.

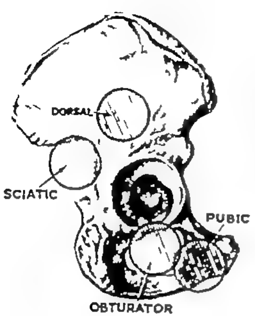


Fig. 1248.—Dislocations of the hip-joint.

Occasionally, when reduction has been accomplished, redislocation occurs as soon as the thigh is extended. The reason for this is that in addition to the dislocation a large fragment of the rim of the acetabulum was detached at the time of the accident. Sometimes redislocation can be prevented by maintaining traction while the limb is extended, and continuing to exert traction until a hip spica has been applied. When this expedient fails, the only effective treatment is to perform, in due course, open reduction with internal fixation of the fragment to its bed.

In every case of dislocation of the hip-joint radiographs should be taken after reduction, not only to confirm reduction, but to exclude fracture of the rim of the acetabulum.

Immediate After-treatment.—The joint is immobilized by applying a plaster hip spica.

Although the hip-joint would appear to be an inherently stable joint, this is not the case, and immobilization for ten weeks is required to enable torn capsule to heal and over-stretched muscle to recover. If the rule of ten weeks' immobilization in a plaster cast is adhered to, the complication of myositis ossificans is extremely rare.

Remote After-treatment.—After the plaster cast has been removed, movement of the joints is regained by active exercises. Weight bearing is permitted only when the

Fig. 1249.—Method of reducing a dislocation of the hip.

muscles that activate the joint especially the abductor group have become plump and firm.

In about 10 per cent of cases avascular necrosis of the head of the femur is inevitable, owing to tearing of the ligamentum teres and the anastomotic branches that nourish the head. Osteo-arthritis is a common sequel

THE KNEE-JOINT

While dislocation is rare subluxation due to rupture of one or both cruciate ligaments is common. When seen early the diagnosis is obvious. A little later effusion renders immediate recognition more difficult. When needed, preliminary aspiration of the joint is advised.

Reduction is effected by extension with traction and direct pressure on the bones. The joint should be immobilized in a plaster cast in slight flexion for three months, followed by appropriate remedial exercises. Instability due to failure of one or both crucial ligaments to unite is not uncommon.

Manipulation of a Locked Knee (Displaced Meniscus).—Full anesthesia is recommended, when frequently the displaced fragment of cartilage goes back into position at the first movement of the knee When this is not the case, the surgeon manipulates the knee in an endeavour to open the medial aspect of the joint, which gives an opportunity for the displaced fragment to be released from its entrapment between the medial condyle and the tibia. When this manœuvre is not followed by the characteristic snap followed by a free range of movement of the joint operation in due course is indicated.

PENETRATING WOUNDS OF JOINTS

Operation in the case of a penetrating wound of a joint is very urgent only by early operation as well as by antibiotic therapy can suppurative arthritis and its crippling aftermath be prevented or minimized. The exception to this rule is a recent puncture by a fine comparatively clean object, such as a needle In such a case the object if still present is removed, the joint is immobilized in the position of rest, and systemic penicillin is administered. As a rule a transitory effusion occurs, which subsides in two or three days. Should this not be the case the directions for the conservative treatment of suppurative arthritis (see p. 900) are followed.

Diagnosis.—Any wound in the vicinity of a joint should be presumed to communicate with that joint until the contrary has been proved. Certain dislocations, e.g. of an interphalangeal joint, are at times associated with tearing of the skin as well as the joint capsule. Compound fracture-dislocations are fairly common at the ankle If penetration of a joint is present or is suspected the patient should be informed, and warned of the possibility of some permanent reduction in the range of movement in the joint. An X ray examination is valuable even if only to exclude the presence of radio-opaque foreign bodies.

First-aid Treatment.—The wound should be covered with a sterile dressing or a clean cloth, and the part splinted

Pre-operative Treatment.—The patient should receive antitetanic serum 1500 units, and penicillin 500 000 units intramuscularly together with pre-operative medication. When necessary operation is delayed until shock has been treated adequately In view of the limited exposure it allows, local anesthesia should be avoided. Brachial block anesthesia (see p. 936) is acceptable in the upper limb but general anesthesia is to be preferred in all cases However trivial the wound appears, if there is a possibility of penetration of the joint, preparation should be made for a major operation.

Operation.—The directions for obtaining swabs of the interior of the wound for bacteriological examination, culture and sensitivity to antibiotics, the preparation of the skin, and the excision of the wound, do not differ from those described on p 184 except in the following particulars the sterile towels are so arranged and fixed with towel clips that the joint can be put through its full range of movement without uncovering unsterile parts. Having excised each layer of the wound when the joint capsule is displayed the fact that it has been penetrated can be confirmed. The damaged capsule and synovial membrane are excised. When retraction of the superficial tissues and the muscles does not give a sufficiently clear view of the joint the wound must be enlarged suitably Gross fragments of dirt and other foreign matter are picked out of the joint with dissecting forceps.

Should foreign matter be embedded in bone or cartilage it is d1 impacted gently with a curette All visible foreign matter having been removed, the interior of the joint is irrigated with saline solution. A most useful method of being enabled to direct a fine stream of the solution into every nook and cranny of the joint is to inject the fluid with a Higginson s syringe to which ha been fitted a Eustachian catheter instead of the usual nozzle After thorough irrigation the synovial membrane is closed with fine interrupted catgut stitches. If the capsule can be brought together without undue tension and the case is an early one the capsule i included in these stitches. Closure of the joint being completed, 1 000 000 units of penicillin are injected into the joint cavity If the capacity of the joint i too small to take the whole of thi dose sufficient of it to fill the joint is injected. The remaining steps of the operation depend upon the interval between the time of wounding and the time of operation —

Less than 6 hours The skin should be sutured If the skin deficiency i considerable proceed a described on p 138

More than 6 hours The skin must not be sutured. The wound is packed lightly with sterile petroleum-jelly gauze

In all cases plintage is essential. A plaster cast which is split completely to permit swelling f the part is usually the most convenient form of splint.

After treatment.– Penicillin therapy in doses of 500 000 units 12 hourly i continued until the wound has healed. If organisms that are insensitive to penicillin are recovered, appropriate change to another antibiotic is made On no account should the wound be inspected in the ward, where every dressing is a potential source of infection or reinfection; all such inspections must be carried out in the operating theatre When the wound has been closed and there are no untoward signs to indicate that all is not well with the wound the first inspection i on the tenth day when the stitches are removed When the wound has been left unsutured it is examined on the fifth day and if it is clean, delayed closure is carried out. When the wound is found t be infected it i lightly repacked and is re-examined after a further interval of 5 days when a decision is made whether to continue with packing or to undertake secondary closure Splintage is retained until the skin wound has healed When the joint i painles and the overlying skin feels cool the splint is removed for a short period and movement are permitted. If no reaction in the joint follows, the splint is discarded and movements are regained with the help of active exercise

Should infection of the joint supervene it is treated as described in the section on acute suppurative arthritis that follows.

ACUTE SUPPURATIVE ARTHRITIS

Usually a purulent exudation into the cavity of a joint is caused by a hæmolytic staphylococcus or a hæmolytic streptococcus less frequently a pneumococcus is responsible and rarely the meningococcus or another organism Infection occurs in one of three ways —

1 Via the blood-stream.

2. By direct introduction of infection through a punctured or lacerated wound.

3. B invasion from a purulent compound fracture or from osteomyelitis of a bone contiguous with the joint.

Local Signs and Symptoms of acute suppurative arthritis include pain in the joint which increases in severity as the joint capsule becomes distended limitation of movement swelling and redness of the overlying skin. Most of the joints of the body (the hip-joint being a notable exception) are sufficiently superficial to allow local signs to be detected fairly easily When a joint becomes acutely inflamed it takes up the position of greatest ease which is, in fact the position of greatest joint capacity The position of greatest ease is in sharp contrast to the position that is most useful hould ankylosis supervene

The general signs, especially in cases of blood borne infections, are typically those of severe toxæmia with a swinging temperature reaching to 103° F (38 0 C) or more There are however numerous exceptions, especially in old age and in infancy For instance D W Hose reviewed 18 cases of acute suppurative arthritis of the hip-joint in newborn infants. In 8 of these all premature infants, the diagnosi remained unrecognized until a swelling of the buttock or thigh, or both, appeared A high temperature was present in only 2 of these patients. At any time of life when infected arthritis complicates septicæmia the profundity of the toxæmia may overshadow the early local manifestations in the affected joint

Joint	Position of Ease	Site of Maximum Swelling	Position for Ankylosis
Wrist	Slight flexion	Under extensor and flexor tendons	Dorsiflexed to allow a firm grasp
Elbow	Flexed at a right angle and pronated	On either side of triceps tendon	90° of extension semi-pronated. If both sides involved, position of one side modified according to occupation
Shoulder	Adducted	Under the deltoid, along the tendon of the biceps, and in the axilla	45° of abduction, and just anterior to the coronal plane and hand in front of mouth
Hip	Flexed, abducted, and externally rotated	Upper part of Scarpa's triangle	[illegible]0 to 30° of flexion to allow sitting, and in neutral position as regards abduction
Knee	Flexed	Suprapatellar pouch and either side of patellar tendon	[illegible] to 10° of flexion to allow foot to clear ground
Ankle	Slightly extended and inverted	Anteriorly and on either side of the tendo Achillis	At a right angle with slight inversion to discourage flat foot

Differential Diagnosis.—

Acute Osteomyelitis is sometimes difficult to distinguish from acute suppurative arthritis; moreover acute suppurative arthritis is not an uncommon complication of acute osteomyelitis of the upper end of the femur. This subject is discussed fully on p. 887.

Acute Arthritis accompanying Bacillary Dysentery is especially liable to follow infection by the Shiga bacillus, and usually the larger joints such as the ankle or the knee are attacked. The comparatively late onset of the arthritis distinguishes it from a serum reaction if serum has been employed. Fluid aspirated from a distended joint will agglutinate the dysentery bacillus. With aspiration, if necessary repeated, complete resolution usually occurs, but in severe cases some degree of fibrous ankylosis is liable to result.

Reiter's Disease (non-specific urethritis with arthritis and often conjunctivitis).—Multiple arthritis is a usual feature of this syndrome. The joints most commonly involved, in order of decreasing frequency, are the knees, ankles, wrists, shoulders, spine and hips. The joints are hot, swollen, tender and acutely painful, especially when moved; the overlying skin often becomes reddened. Occasionally a pneumococcal-like organism has been isolated from the synovial fluid. This infection is resistant to all antibiotics.

Gonococcal Arthritis.—The usual form of arthritis following gonorrhoea is identical with that following non-specific urethritis. When the gonococcus cannot be found in the urethral discharge, a positive complement fixation test of the serum or the joint fluid clinches the diagnosis. A response to systemic penicillin is usually complete and prompt. In the occasional penicillin-resistant case, combined aureomycin and streptomycin has proved successful.

Rheumatic Fever.—The most characteristic feature of this arthritis is that the pain flits from joint to joint, and the arthritis is always multiple. The disease involves the larger joints. Signs of cardiac involvement are usually manifest.

Diagnostic and Therapeutic Aspiration must always be undertaken in the operating theatre. That the synovial fluid is purulent, semipurulent, or hazy clinches the diagnosis of infected arthritis there and then. In these circumstances as much of the synovial fluid as possible is aspirated, and 1 000 000 units of penicillin are injected into the joint. In the case of a small joint this amount could not be accommodated, and the joint is filled to capacity. A generous sample of the aspirated fluid is sent to the bacteriologist with the usual request for isolation of the organism or organisms present, and their sensitivity to antibiotics. What is also highly important is to send a specimen of the patient's blood for culture at the same time.

Splintage.—The joint is splinted in the best position for ankylosis, should it occur. Plaster splints are convenient in many situations. A Thomas's splint is adequate for the knee joint, and can be used for the hip-joint if skin traction is applied to the leg

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Splintage.—The joint is splinted in the best position for ankylosis, should it occur Plaster splints are convenient in many situations. A Thomas's splint is adequate for the knee-joint, and can be used for the hip-joint if skin traction is applied to the leg

Notwithstanding the most desirable method of immobilizing the hip-joint is by means of a Robert Jones abduction frame

General Treatment.—

1. Penicillin 500 000 units, is given 12 hourly for three weeks, unless the bacteriological report indicates that another antibiotic should be substituted

2. An *adequate fluid intake is essential. If this is not possible orally* dextrose-saline is given intravenously until the patient is able to take sufficient fluid by mouth In cases of septicæmia blood transfusion or an exchange transfusion is often indicated

3. Rest is vital and pain should be relieved by morphine

Local Treatment.—

1. The joint is aspirated daily and 1 000,000 units of penicillin, or an appropriate dose of such other antibiotic as the culture indicates, is injected.

2. When the joint is infected because of a penetrating wound or an open fracture that communicates with the joint general surgical principles demand adequate toilet of the wound, and skin cover as soon as the underlying tissues present a healthy appearance

Radiological Examination.—Periodic radiographs are desirable with a view to demonstrating local bony changes or the development of a pathological dislocation, both of which *are to be regarded as evidence of inadequate treatment*

When Therapeutic Aspiration with Antibiotic Therapy bids fair to control the Disease.—In the majority of cases the treatment detailed above brings about a favourable response as shown by lessening of the toxæmia, a fall in the temperature and progressive relief of pain in the joint The effusion decreases in amount, and becomes less obviously purulent Aspiration of the joint and intra-articular injection of an antibiotic can cease when the effusion is small and is sterile on culture Parenteral antibiotics are continued for three weeks. When the joint is cool and painless, and there is no pyrexia and no muscle spasm, splintage is discarded. If this does not result in a recrudescence of symptoms, active exercises are commenced to restore joint movement and muscle bulk and tone

When Therapeutic Aspiration and Antibiotic Therapy prove insufficient to control the Disease.—The problem is an onerous one The first consideration is to save the patient's life a secondary matter is, if possible to preserve the limb taking into consideration that a varying degree of ankylosis or a flail joint is a foregone conclusion

What not to do Experience of the second world war and the Korean war proved as earlier experience had indicated, that thorough continuous drainage of a joint is not feasible Incisions for draining a joint serve only as avenues for overflow the intra-articular suppuration persists, often with continuing proteolytic digestion of articular cartilage Continuous drainage of fluid from a joint is contra-indicated for other reasons :

1. An open wound of the joint is liable to become secondarily infected.

2. The nutrition of the articular cartilage is reduced by the continual loss of synovial fluid.

3. Dense intra-articular adhesions are almost inevitable

4. The antibacterial action of the synovial fluid, if any is lost

Modified Arthrectomy In post traumatic suppurative arthritis the nidus of persistent infection is almost always devitalized articular cartilage It is safe to assume that in cases of acute hæmatogenous infection that show little or no response in four days to therapeutic aspiration combined with local and systemic antibiotic therapy the articular cartilage is irreparably damaged. Experience particularly military experience has proved that excision of devitalized tissue within the joint—usually articular cartilage—followed by closure of the synovia, is the treatment of election in comparatively early cases of suppurative arthritis which fail to respond to therapeutic aspiration with antibiotic therapy or where therapeutic aspiration is inapplicable Should the damage be found to be so extensive as to preclude future function morbidity can be reduced and the best possible function obtained by a more formal resection of the joint

Whichever technique is employed, the operation should be performed promptly because the hyaline component of articular cartilage is destroyed rapidly by a proteolytic enzyme present in the purulent exudate

Amputation. In grave cases of suppurative arthritis that do not respond to conservative treatment the advisability of performing timely amputation should receive carefully weighed consideration. In situations where an artificial limb is highly satisfactory the responsibilities of advising an amputation that will almost certainly cure the patient and

cure him quickly are not great seeing that the alternative is, at the best, a stiff or partially stiff and often painful joint.

EXPOSURE OF JOINTS

Individual joints will be considered in the order of frequency with which the need for operation is likely to be encountered.

Exposure of the Knee-joint.—Timbrell Fisher's incision (*Fig.* 1230) gives good access. The various layers are deepened in the line of the incision until the joint is opened. The patella can then be displaced laterally. The joint is cleansed of pus and exudate. The articular surfaces of the femur and the tibia are inspected carefully; upon their appearance rests the decision as to whether the joint can be saved, or is doomed. Unhealthy cartilage must be excised. If the menisci are softened and dull, they are removed. The articular surface of the patella is inspected. If its cartilage ppears dead the patella is excised—the loss f the patella is a small price to pay for en ancing the chances of preserving the joint. If e patella is not removed a second incision ng the outer border of the patella is often cessary so as to be enabled to attend to the icular surfaces on the lateral side of the it. All devitalized cartilage having been oved, the joint is irrigated with normal saline solution. The synovial membrane and sometimes the capsule is closed tightly. Penicillin is injected into the joint.

Fig. 1230.—Timbrell Fisher's incision for exposing the interior of the knee-joint.

Modified Resection of the Knee-joint is a last hope of preserving the limb to be employed only when the cartilage covering the ends of the bones is obviously infected. Timbrell Fisher's incision having been made, flexion of the knee provides exposure of the femoral condyles and the head of the tibia. The patella is excised unless its cartilage is healthy, which is unusual. The tibial articular cartilage together with a thin margin of bone is resected. The condyles of the femur are also resected at the level of the anterior border of the articular cartilage. Both these sections are made with a saw, a Gigli's saw being well adapted for this purpose. The joint surfaces are removed, together with the menisci and the cruciate ligaments. The excision being completed, the ends of the bones are approximated to reduce dead space and promote fusion. Because all dead space cannot be eliminated, a soft rubber drain is inserted. The wound is left open, including the capsule and the synovia, and the superficial part of the wound is packed lightly with petroleum-jelly gauze. Immobilization is provided by a single hip-spica plaster cast extending to the ankle. Five days after the operation the wound is examined under anaesthesia, drains are removed, and the depths of the wound are irrigated thoroughly. Should the appearance of the wound warrant it, delayed closure is carried out. In other circumstances the wound is again repacked and inspected after a further interval of five days, with the same objective in view. Needless to say, antibiotic therapy is continued until the wound has healed.

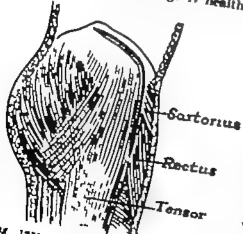

Fig. 1231.—Smith-Petersen's approach to the hip-joint.

Exposure of the Hip-Joint.—Although anterior or posterior drainage had been employed in 26 cases of suppurative arthritis of the hip-joint following wounding, control of the infection and healing occurred in only 2 (O. P. Hampton). This, in itself, is evidence that if therapeutic aspiration fails, more radical measures than drainage of the joint are of cardinal importance.

The Anterolateral Approach of Smith Petersen gives excellent exposure with a minimum loss of blood. The incision passes from just below the middle of the iliac crest to the anterior superior iliac spine, then vertically downwards for 4–5 in. (10–12.5 cm.) (*Fig.* 1231). The superficial and deep fasciæ are divided in the line of the incision, and the origins of the gluteus medius and tensor fasciæ latæ are erased subperiosteally from the ilium and reflected downwards. Attention is then directed to the vertical portion of the incision. The interval between the sartorius and rectus femoris anteriorly and the tensor fasciæ latæ posteriorly is sought, and these groups of muscles are separated by sharp and blunt dissection. This

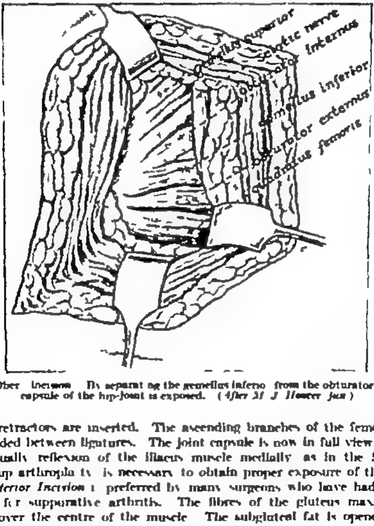

Fig. 1232.—Ober incision. By separating the gemellus inferior from the obturator internus, the capsule of the hip-joint is exposed. (*After M. J. Hoover, jun.*)

accomplished, retractors are inserted. The ascending branches of the femoral circumflex vessels are divided between ligatures. The joint capsule is now in full view, and is incised vertically. Usually reflexion of the iliacus muscle medially, as in the Smith-Petersen approach for cup arthroplasty, is necessary to obtain proper exposure of the acetabulum.

Ober's Posterior Incision is preferred by many surgeons who have had experience of this operation for suppurative arthritis. The fibres of the gluteus maximus are split longitudinally over the centre of the muscle. The subgluteal fat is opened up and the sciatic nerve is identified. Later the nerve is retracted medially. The gemellus inferior is separated from the tendon of the obturator internus (*Fig.* 1232). The posterior aspect of the capsule of the hip-joint is now exposed. It is incised vertically.

The object of the operation is to erase all infected cartilage. Dislocation of the head of the femur is sometimes necessary for this purpose. At the completion of the intra-articular part of the operation, when possible the joint is closed, after which penicillin is instilled into it. In many instances such closure will be found impracticable. In that event posterior drainage is instituted. Closure of the hip-joint is less important than in the case of other joints, because the hip-joint is so well protected from secondary contamination by its complete muscular investment.

A hip plaster cast which extends to the toes is applied, or a half ring Thomas's splint with skeletal traction and balanced suspension from an overhead Balkan frame can be substituted.

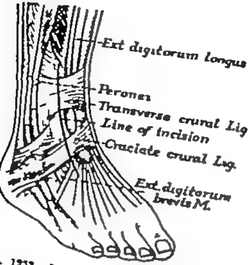

Fig. 1232.—Incision for exposure of the ankle joint. (After W. C. Campbell.)

Fig. 1234.—Incision for Henry's approach to the shoulder joint

Exposure of the Ankle Joint.—The anterolateral approach cannot be bettered. The incision commences in front of the fibula 2 in. (5 cm.) above the joint and is carried downwards between the lateral malleolus and the peroneus tertius, to end at the base of the fourth metatarsal. Both extensor retinacula are divided (*Fig* 1233).

Fig 1233.—The joint is reached between the triceps and brachioradialis above and the anconeus and radial extensors below

Fig 1235.—Wonderful exposure without mutilation is afforded by following Kocher's method.

Exposure of the Shoulder Joint.—The patient lies on his back with the shoulder raised slightly by a flat sandbag. The arm should be so wrapped that the limb is freely movable at the joint during the operation. The incision commences behind the highest point of the shoulder over the spine of the scapula and passes downwards over the medial border of the deltoid as far as its insertion (*Fig.* 1234). The cephalic vein is identified, and avoided by deepening the incision through the medial fibres of the deltoid. The anterior part of the deltoid is detached from the anterior border of the lateral third of the clavicle by severing a thin slice of bone from its border with a chisel. Splendid exposure of the shoulder joint is thus obtained.

At the close of the operation the slice of bone with the muscle attached, is replaced, and retained with a single stitch.

Exposure of the Elbow Joint.—Kocher's method is excellent. The incision commences 2 in. (5 cm.) above the lateral epicondyle and passes downwards to the back of the head of the radius, and then curves medially over the lateral border of the anconeus, to end over the superficial border of the ulna (*Fig.* 1255). The interval between the brachioradialis and the triceps in the upper part and the carpal extensors and the anconeus in the lower part of the incision is defined and these groups of muscles are separated down to bone. The muscles on each side of the incision are erased subperiosteally. The capsule of the joint is incised and the head of the radius and ulna can be subluxated laterally exposing the whole of the interior of the joint (*Fig.* 1256).

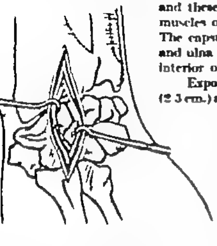

Fig. 1257.—Exposure of the wrist joint. (*After H. S. Dickson.*)

Exposure of the Wrist Joint.—The incision is commenced 1 in. (2.5 cm.) above a point midway between the styloid processes of the radius and ulna, and passing along the lateral aspect of the extensor carpi radialis longus is continued downwards vertically to the middle of the base of the second metacarpal. The posterior retinaculum is divided in the line of the incision. The tendon aforesaid and that of the extensor pollicis longus are retracted laterally and the incision is deepened to the bone. The insertions of these tendons are then detached subperiosteally. The hand is flexed so as to make the wrist joint more prominent and the capsules of the joint are incised (*Fig.* 1257).

Exposure of the Interphalangeal and Metacarpophalangeal Joints.—Suppurative arthritis occurring in these joints is usually the result of a lacerated wound on which débridement has not been carried out or has been carried out incompletely. In some cases the patient has failed to report until the joint is infected. Often the extensor tendon has been severed. Should it have been sutured, the sutures are removed. The wound is excised and all infected cartilage and, if present, infected bone is removed. The wound is closed by a figure-of-8 stitch of stainless steel passing through the tendon and the skin.

When the tendon is intact the joint is approached by a dorsilateral incision. If the exposure thus afforded is insufficient to see the ends of the bone clearly it is better to sever the tendon partially or completely than to divide a lateral ligament: the tendon can be repaired at the conclusion of the intra-articular portion of the operation.

Healing with good movement is achieved in 50 per cent of cases. In the remainder the discharge ceases, but the digit is stiff, or has very restricted movement. In all cases of modified excision of a joint antibiotic therapy should be continued for fourteen days.

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Revised with the help of Dennis Walker, M.B., B.S. (Lond.), F.R.C.S. (Eng.), *Consulting Orthopaedic Surgeon, Ashford Hospital, Middlesex*

CHAPTER LXXIX

NERVES AND TENDONS

SEVERED NERVES

REGENERATION of a nerve occurs at the rate of 1 mm. a day; consequently after suture of a severed nerve there is bound to be a long interval before the parts supplied by that nerve will function once more. Obviously, therefore, one would think that if circumstances are favourable it would be advantageous to effect union at the time of the original operation. Another advantage of primary suture is that technically it is less difficult than secondary suture. At a secondary operation the cut ends of the nerve are liable to be encased in fibrous tissue; retraction of the ends has occurred, and a bulbous neuroma requiring resection surmounts each end, and adds to the length of the gap that must be overcome before the freshened ends can be approximated without tension. On the other hand severed nerves at secondary repair have one advantage: fibrosis having occurred, the ends are firm and the epineurium holds sutures comparatively well.

Massed statistics (mostly war injuries) show that the results of secondary suture are better than those of primary suture (B. Woodhall). What is even more authoritative are the findings of the Nerve Injuries Committee of the Medical Research Council, who recommend that primary suture, even for nerve injuries due to clean incised wounds, be abandoned. In spite of these weighty pronouncements, it must be remembered that they concerned mainly war injuries, and whether or not to employ primary suture in suitable cases in accidents in civil life is still controversial. M. L. Mason, writing subsequently, states that the surgeon dealing with wounds of the hand (and wrist) prefers, when possible, to carry out primary suture, reserving for secondary repair those cases in which contamination or age of the wound contra-indicates suture. Professor Bogdanov writing in 1955 states that "In the USSR we aim at accurate suturing of damaged nerves at the primary operation."

To suture or not to suture—a compromise: When conditions are favourable for primary suture (i.e., healing of the wound by first intention is anticipated) but for one or other reason it is considered wiser to postpone effecting the anastomosis, it is a good practice to insert one fine tantalum wire suture through the nerve-ends in the manner shown in *Fig.* 1238 and to tie it just tight enough to approximate the cut surfaces. This stitch is not intended as a means of effecting union, but as a temporary expedient to prevent retraction of the nerve-ends, and to enable the site of severance to be identified radiologically before secondary suture is carried out.

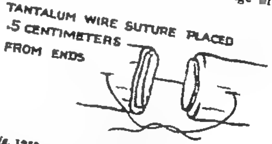

Fig. 1238.—To prevent retraction of the nerve-ends a fine tantalum wire suture is placed 0.5 cm. from the ends. (*After C. E. Troland.*)

Secondary Suture.—When the wound heals by first intention, secondary suture can be carried out twenty to thirty days after injury. If suppuration occurs the operation should not be attempted until at least a month after the wound has healed soundly.

NERVE SUTURE

Materials.—Although advocated by some, wire sutures tend to cut through the epineurium (E. A. Spigel). Catgut provokes an inflammatory reaction and is condemned by all. Favourable results have accrued from the employment of the finest black silk mounted on eyeless needles, such as are used in blood-vessel surgery. Very fine cotton on a dress-maker's needle also has given satisfactory results. The finest nylon sutures are admirable.

will protect this region, and the expedient seems preferable to other substances that have been used for the purpose

Partial Division.—If a few drops of saline solution are injected beneath the epineurium with a hypodermic syringe 1 cm. above and 1 cm. below the laceration, it will be found that the divided nerve-bundles are much easier to identify. The severed bundles are trimmed without disturbing the remaining intact fibres. The sheath is then incised longitudinally for a short distance so that the injured nerve-fibres can be separated gently from those that are intact (*Fig* 1260 A). The epineurium of the divided bundles is united by end to-end suture, while the intact part of the nerve remains as a lateral loop (*Fig* 1260 B)

Epineural and Endoneural Hæmatomata.—After injecting a little saline solution beneath the epineurium in the vicinity of the lesion, the epineurium is split and blood-clot which, if left, would favour neuroma formation is syringed out with a fine stream of saline solution directed through the needle of a hypodermic syringe. The sheath of the nerve is left unsutured.

EXPOSURE OF INDIVIDUAL NERVES

Median and Ulnar Nerves at the Wrist.—The majority of cases of cut nerves requiring immediate suture are caused by incised wounds in the vicinity of the wrist. The position of the median and ulnar nerves in relation to surrounding tendons is shown in *Fig* 1276.

While suture of these nerves in this situation presents no particular difficulty it is essential to obtain wide exposure so that the nerve-ends can be identified although it seems unlikely a mistake that has often been made is to suture the divided median nerve to the divided palmaris longus tendon.

Digital Nerves are also frequently divided in wounds involving the sides of a finger Since anæsthesia of a finger is a considerable handicap, these nerves should be sought carefully and if possible repaired by primary suture. The digital nerves are structures

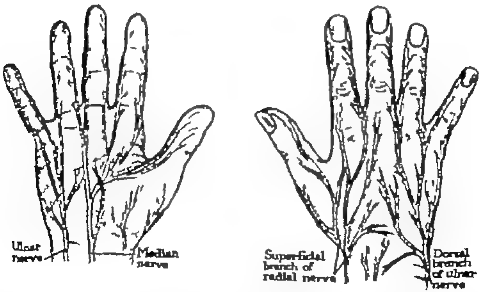

Fig 1261 —The digital nerves. (*After Phil Thorek.*)

of appreciable size, and their repair is not so difficult as might be supposed, and the results are often particularly gratifying the same is true for all the nerves of the hand (*Fig* 1261).

Having dealt with these common lesions, it is necessary to pass on to some nerve injuries in other situations that require more detailed consideration

Brachial Plexus.—The entire plexus can be exposed by the incision recommended for displaying the subclavian and axillary arterial trunk (see p. 940). The upper portion of the plexus lies behind the scalenus anticus muscle, which must be divided in necessary cases. Wounds of the brachial plexus that require resection of more than 1 in. (2 5 cm.) of the nerve-bundles are almost impossible to treat, because of the difficulty in securing relaxation.

Shortening the divided clavicle is helpful in this respect and some tension can be relieved by elevating the shoulder and flexing the arm across the chest.

Median Nerve.—Shortly after its origin in the brachial plexus, good exposure of the median nerve can be obtained by an incision passing along the anterior border of the deltoid and along the bicipital groove. A lesion in the middle of the arm is exposed easily by a straight incision along the sulcus between the triceps and biceps (*see Fig.* 1314, p. 948). A double flap incision (*Fig.* 1262) is desirable at the elbow where the nerve passes between

Fig. 1262.—Double flap incision for exposing the median nerve at the elbow. This incision avoids flexion contracture. (*After C. E. Troland.*)

the two heads of the pronator teres. Some relaxation of the nerve can be obtained by dividing one of these muscular bundles. Important motor fibres to the flexor muscles originate at this site and great care must be taken to avoid injuring them. Below the elbow the nerve runs a straight course lying on the flexor digitorum profundus and covered by the flexor digitorum sublimis. Considerable relaxation of the distal end of the nerve can be obtained by flexion of the wrist.

A lesion of this nerve at the wrist has been considered on p. 913.

Radial Nerve below and in its Groove.—The arm should be laid across the chest. The hand may be attached to the operating table by a length of bandage. Identify the lateral epicondyle. Above it by palpating deeply the supracondylar ridge can be felt. Here arises the brachioradialis. Commence the incision between the *origin of the brachioradialis* and the brachialis, and carry it upwards in the direction of the spiral groove. Dissect in the interval between the brachioradialis and the brachialis. The radial nerve will be found lying very deeply in this groove, the depth at which it lies differentiating it from the more superficially placed musculocutaneous trunk. The nerve is now traced upwards. Towards its groove it will be found to pass deep to the outer head of the triceps. The outer head of the triceps arises by a flattened tendon from the back of the humerus. By dividing this outer head and the aponeurotic bridge across the spiral groove an excellent view is obtained. The radial nerve and the profunda brachii artery are displayed (*Fig.* 1263).

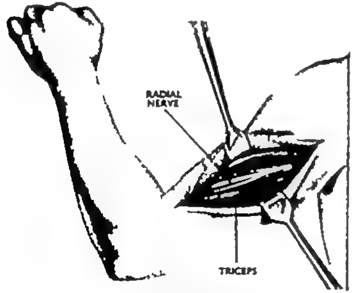

Fig. 1263.—Exposure of the radial nerve in its groove. The triceps has been divided.

Posterior Interosseous Nerve.—The course of this nerve being short and winding as it does around the lateral aspect of the neck of the radius in the fibres of the supinator muscle, it is well protected. Consequently it is injured rarely. For this very reason should a case of injury of this nerve be encountered, the surgeon will be in need of instructions for exposing it. Being a purely motor nerve its suture yields most satisfactory results.

The arm lies across the patient's chest. Palpate the head of the radius. Commence the incision over the head of the radius and carry it down the shaft rather nearer the posterior than the anterior aspect. Expose clearly the common extensor origin and find the interval

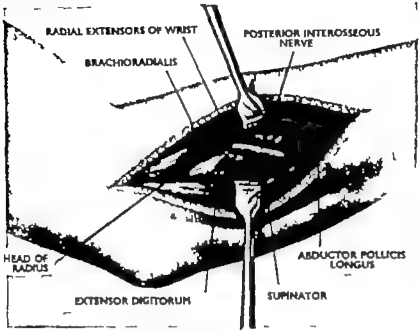

Fig. 1264.—Exposure of the posterior interosseous nerve. (*After Sir Henry Souttar.*)

between the extensors of the wrist laterally and those of the fingers medially. The extensor digitorum is thus separated from the extensor carpi radialis brevis and the supinator comes into view. Palpate this muscle. If the nerve cannot be felt winding around the neck of the radius, it must be sought deliberately. It can be found on the *back* of the radial shaft at a quite definite point—three finger breadths distal to the head of the radius (A. K. Henry). Incise the muscle and the nerve is exposed (*Fig.* 1264).

Ulnar Nerve.—

In the Upper Arm the ulnar nerve can be exposed by an incision similar to that for the brachial artery (*see* p. 948). As far as the middle of the upper arm the nerve lies in close relationship to the artery. In the lower half of the upper arm it inclines increasingly medial to the artery lying upon the medial belly of the triceps muscle.

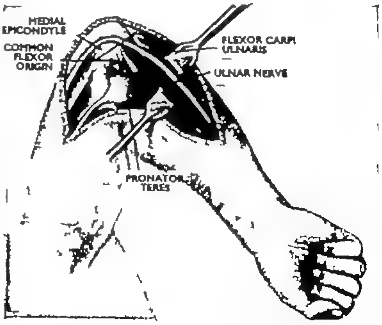

Fig. 1265.—Exposure of the ulnar nerve at the elbow before transplanting it in front of the medial epicondyle.

At the Elbow.—In addition to suture, the nerve should always be transposed in front of the medial epicondyle and a bed made for it in this situation. For this procedure it will be found convenient to have the arm across the patient's chest and to stand facing the forearm—that is, to stand on the side of the sound limb. If the lower part of the forearm and the hand are wrapped in a sterile towel, the hand and forearm can be twisted into various

positions to suit particular circumstances at various stages of the operation. The incision follows the ulnar groove passing in a straight line from a point 1 in. above the groove to 3 in. below the groove.

The proximal end of the nerve is dissected up with due regard for its muscular branches. Likewise the distal end is followed freeing it from the fascia which bridges the ulnar groove. Proceeding the nerve is traced under the fascia covering the common flexor origin—it will be seen to dive under the fibrous arch uniting the heads of the flexor carpi ulnaris. There is no difficulty in following it for some distance and it can be mobilized readily.

Both ends having been mobilized, twist the forearm so that the front of the epicondyle is visible. Bring the nerve-ends anterior to the epicondyle and unite them in this anterior position. As the nerve lies loosely on the front of the elbow it is obvious that a bed for it can be made very simply. Make an incision about half an inch deep in the common flexor origin (*Fig.* 1205). Place the nerve into the furrow and bury it neatly by sewing the divided muscle over it. When the operation is completed, bandage the flexed arm to the side.

Sciatic Nerve.—The patient should lie on his face.

In the Buttock the nerve can be exposed by the method described for displaying the superior and inferior gluteal arteries (see p. 933).

In the Thigh.—Take a point slightly medial to midway between the greater trochanter and the tuber ischii: this is the surface marking. Commencing just below the gluteal fold, make an incision passing directly downward. Identify the hamstring muscles, and retract them medially. Although deeply placed in the wound, usually the sciatic nerve will be found without difficulty. In muscular subjects the gluteal muscles must be retracted upward (*Fig.* 1206). The bifurcation of the sciatic nerve into its two terminal divisions is not constant; sometimes the nerve divides high in the thigh. As soon as the cut ends of the nerve have been located the knee-joint should be flexed: this lessens tension considerably. After the nerve has been sutured and the skin wound closed, the limb must be immobilized in a position that will reduce tension on the nerve to a minimum.

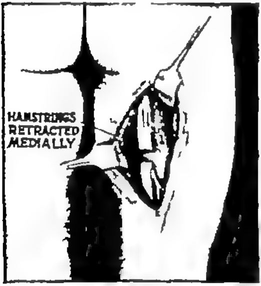

Fig. 1206.—Exposure of the sciatic nerve.

Fig. 1207.—Plaster shell for maintaining the desired position after suture of the sciatic nerve.

Post-operative Position of the Limb.—Hyperextension of the hip and full flexion of the knee must be maintained. When an elective operation is to be performed this position is best obtained by making a removable plaster shell extending from the upper abdomen to the ankle (*Fig.* 1207). The application of an extensive plaster cast at the conclusion of an operation for repair of the sciatic nerve adds greatly to the shock, therefore this shell should be made some days before operation on the nerve is undertaken. Alternatively after primary suture, if that be thought desirable, the position can be achieved by bending a Thomas's splint suitably. In either event the patient is nursed prone for 48 hours, and then is turned on to his side. At the end of a fortnight slight flexion of the hip can be permitted; three weeks later gradual extension of the flexed knee is commenced.

The Femoral Nerve.—Unless the nerve is found to be injured above its high division into numerous branches, this is a most difficult nerve to repair and partial success is all

that can be achieved. The femoral nerve is displayed as for exposure of the upper part of the femoral artery (see p. 931).

Medial and Lateral Popliteal Nerves in the Popliteal Space should be exposed by a ⌐ incision to avoid flexion contracture. After completion of the operation a plaster cast is applied with the knee-joint flexed to a right angle.

The Lateral Popliteal Nerve and its Branches.—The patient lies on the sound side three-quarters prone, with the hip and knee flexed. The incision follows the biceps tendon in the thigh, and extends to in front of the neck of the fibula. When the distal part of the popliteal nerve (anterior tibial nerve) requires freeing, the incision can be prolonged over the upper part of the anterior compartment of the leg. After the deep fascia has been divided the biceps is retracted, and the nerve is displayed easily. Traced downward, the nerve passes beneath the upper part of the peroneus longus, which is divided as necessary. To obtain sufficient relaxation for anastomosis, usually it is necessary to mobilize the sciatic nerve for some distance. Suture is carried out with the knee flexed, and at the conclusion of the operation flexion is maintained by a plaster cast.

The Posterior Tibial Nerve.—The incision is commenced in the popliteal space, and the medial popliteal nerve is traced downward, the various layers of the calf being split as directed on p. 953.

SEVERED TENDONS

In civil life about 90 per cent of cut tendons concern the hand and wrist. The complex nature of the flexor tendons of the hand renders their repair a more difficult problem than that of other tendons. The tremendous importance of tendons of the hand to the earning capacity of the individual makes this a subject worthy of especial study. Accurate and adequate notes on the injury and operative treatment are essential, not only for their own sake, but to refresh the mind during the litigation which so often follows.

First aid Treatment has a much greater bearing on selecting cases for primary suture and on the prognosis than has been hitherto accredited to it. It should be taught emphatically that the first-aid treatment is :—

Cut flexor tendon. Flex all the joints activated by the cut tendon and immobilize securely.

Cut extensor tendon. Extend all the joints activated by the cut tendon and immobilize securely.

It is the contention of the Russian surgeons that the ill-repute of 'no-man's-land' is due, not to some factor which is difficult to explain, but to abrasion of the delicate lining of the tendon-sheath when endeavouring to retrieve tendons that have retracted within the sheaths. Correct first-aid treatment, therefore, greatly minimizes post-operative adhesions—the bugbear of tendon suture.

Fig. 1203. — No-man's-land. It extends from the middle palmar crease to the middle crease of each finger.

'No-man's-land.'—The usual poor results of repair of flexor tendons in this zone, so picturesquely described by S. Bunnell, have led many surgeons to abstain from performing primary repair in favour of secondary repair by means of tendon grafting. The zone extends from the middle palmar crease proximally to the middle crease of each finger distally (*Fig.* 1203). To this zone G. Pulvertaft has added (for another reason (see p. 921)) that part of the sheath of the flexor pollicis longus within the thenar eminence. A growing number of surgeons now maintain that under proper conditions, with certain steps in technique, notably by the employment of a 'pull-out' suture, the ban in this area can be lifted.

Primary Suture of a Tendon should *not* be attempted :—

1. If more than 8 hours have elapsed since the time of severance.

2. In crushing injuries in which fractures, bursting of tendon-sheaths, and loss of skin have occurred.

3. When necessary débridement is such that a dead space is left, and a tendon, if sutured, would span a cavity.

4. When it has been decided to leave the skin unsutured.

5. When, owing to the extent of other injuries or the poor condition of the patient there is insufficient time to repair the tendon or tendons meticulously

Injuries inflicted by the human teeth, and injuries due to the fishmonger's or butcher's knife should not be subjected to primary tendon suture or primary closure either for that matter

REPAIR OF CUT TENDONS

Some General Principles.—Operations for repair of cut tendons should not be carried out in the casualty department the patient requires admittance and an operation in the general theatre

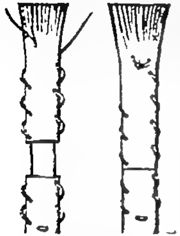

Fig. 1269 —Method of suturing a large flat tendon.

Local anæsthesia is often adequate Most of the operations for suture of tendons of the hand performed by Russian surgeons are carried out under this form of anæsthesia. The Russian surgeons advise against the use of a tourniquet in this way hæmatoma formation is prevented. Many European and American surgeons recommend the use of a pneumatic tourniquet, but this is not in accordance with the best technique of débridement (see p 184). Possibly these conflicting instructions have arisen because the Russian surgeons carry out primary suture whenever conditions permit whereas many other surgeons are concerned mainly if not entirely with secondary repair where there is no contra-indication to the use of a tourniquet.

Methods of enlarging the wound for repair of a severed tendon of the hand or a digit are described and illustrated on p. 903.

When the proximal end of the tendon cannot be found in the wound, do not grope for it blindly with a hæmostat other structures, especially nerves, are liable to be endangered in this way A s rule it is best to make a transverse incision 2–3 in. (5–7.5 cm.) above the wound, and *examine systematically the underlying anatomy The missing tendon surely will be found* Pass a hæmostat from the first to the second wound grasp the free end of the tendon and draw it down.

After-treatment of Sutured Tendons—The limb must be immobilized in whatever position is best to relieve all pull on the sutured tendon. In the case of the hand or wrist a plaster slab, with the affected joint flexed or extended as the case may be cannot be bettered. It has been shown fairly conclusively that tendons unite firmly in a period of 2½–3 weeks. Following tendon repair most surgeons immobilize the area for a period of 3 weeks.

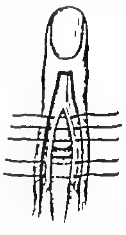

Fig. 1270.—Method of repairing an extensor tendon severed over the proximal phalangeal joint.

Flat Tendons. A large flat tendon can be repaired with a stainless-steel wire suture inserted as shown in *Fig* 1269 After the sutures have been tied the junction is reinforced by a few interrupted stitches of very fine silk

The Extensor Tendons of the Hand are repaired most satisfactorily by end-to-end anastomosis with interrupted sutures of 000000 silk in this situation it is best to avoid sutures of wire because of its tendency to bunch the tendon and in the dorsal surface of the hand there is inadequate soft tissue protection to make the wire knot impalpable Meticulous end-to-end approximation with 000000 silk on an atraumatic needle with three knots, and the suture cut flush to the last knot has given the best result (C. E. Nemethi).

The Extensor Tendon over the Proximal Interphalangeal Joint is often difficult to approximate by the usual methods sutures in the distal part of the central portion of the

[1] As in the case of nerve suture, never use catgut for suturing a tendon, because of the reaction it provokes.

extensor expansion are liable to cut out The following method is therefore advised. The wound having been enlarged in a ⊔ manner the aponeurosis is dissected so as to define the lateral bundles. These are approximated by transversely placed stitches (*Fig* 1270) with the finger in extension, five to six sutures being used The stitches include not only the lateral bundles, but also where available the severed middle bundle of the long extensor (Weinstein).

Results of Primary Repair of Extensor Tendons of the Hand are very good indeed. In the best series 92 per cent of the patients have regained full function

Round Tendons.—

The Bunnell Mayer Suture —The standard method of repair is by the Bunnell Mayer suture. Fine (preferably braided) stainless-steel wire (No 30–40 S W G) on an atraumatic needle is by far the best suture material as it involves so little tissue reaction. The extreme cut end of the tendon is held in a hæmostat commencing about 1½ in. (3 8 cm.) away from the cut end, a double right angle stitch is inserted—usually three twin bites are taken.

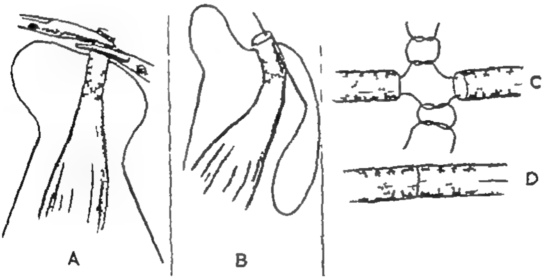

Fig 1271 —Steps in the Bunnell Mayer suture for round tendons. Note that the knots are counter-sunk between the divided ends of the tendon.

The end of the tendon is then trimmed with scissors (*Fig* 1271 A) and the stitches are brought out near the centre of the cut surface of the tendon (*Fig* 1271 B) An exactly similar stitch is inserted into the other end of the tendon. Each end of the suture is tied to its counterpart (*Fig* 1271 C) thus the knots lie buried between the cut ends of the tendon (*Fig* 1271 D) so that only a minimum of suture material remains on the surface to interfere with gliding

The Barb Wire Method of Primary Suture of a Tendon.—If this wire suture is available, it is an admirable method of anastomosing flexor tendons of the palm or fingers, but is applicable to the repair of any tendon. The use of this expedient avoids burdening the tissues with a considerable amount of suture material, does not leave knots between the stumps, and does not strangle tissues. The suture consists of braided tantalum wire with needles affixed, and it should be noted that the barbs point towards the straight needle (*Fig* 1272 *inset*).

Technique —The straight needle is threaded through the centre of the proximal segment of the tendon, until the barb is engaged. The same needle is then inserted through the mid portion of the distal segment and brought out through the skin. Adequate tension is placed on the distal portion of the suture, thus approximating the severed ends of the tendon (*Fig* 1272). Tension is maintained by means of a button with a match-stick or lead shot. The proximal portion of the suture is made to emerge through the skin by means of the curved needle It is then anchored loosely over a button in the way described for its fellow After the severed tendon has healed, the suture is cut below the distal button and removed by a gentle pull on the proximal button. Because of the simplicity and the ease of

application of this suture It is likely that this will prove a great asset in the repair of tendons, especially those of the hand

Bunnell's pull-out Tendon Suture was designed for the repair of a flexor tendon within a sheath, on the theory that absence of a suture left the repaired tendon in a better condition and freer from adhesions than would be the case in the presence of any suture Tension or pull on a tendon suture is from one end only—that to which the muscle is

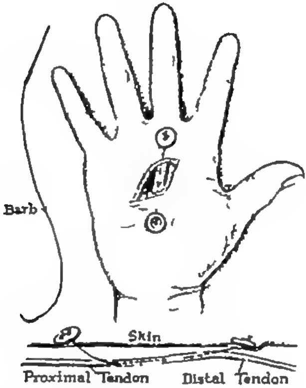

Fig 1272.—Method of approximating a severed tendon with barb wire (*E. R Jennings et al*)

attached—the other end of the tendon remaining passive therefore the suture (wire) is spliced to the proximal end only It is passed down the distal end and made to emerge through the skin, there to be fastened firmly to a button (*Fig* 1273). The proximal end is thereby held distal-wards against the passive distal tendon end. The suture is rendered removable by threading a piece of wire under the proximal loop of the stitch. Both ends of this wire are threaded on *the same* curved needle and passed through the skin proximal to the junction, and either left there or more usually tied very loosely over a button.

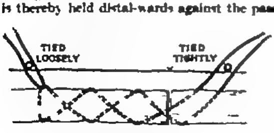

Fig 1273.—Bunnell' pull-out suture

Removal—Three weeks later after sterilizing the skin under the distal button, the wires are cut at skin level. A small rubber band is then attached to the pull-out wire or its button, the other end of the rubber band is passed over a narrow strip of adhesive plaster which in turn is stuck to the forearm. Within 24 hours the suture will be out

DIGITAL FLEXOR TENDON SEVERANCE AT VARIOUS LEVELS, AND THE TREATMENT RECOMMENDED

Anatomical Arrangement of the Tendons.—The sublimis is superficial. The way in which the sublimis bifurcates to permit the profundus to pass through it is shown in *Fig* 1274 The sublimis is inserted into the sides of the shaft of the middle phalanx. The

profundus is inserted in the base of the terminal phalanx The function of the sublimis (flexion of the proximal phalanx on the metacarpal and flexion of the proximal inter phalangeal joint) can be carried out by the profundus but full flexion as in grasping is less strong

1 **Severed Sublimis only**—Because it is more superficial when a single flexor tendon of a digit is severed, usually it is the sublimis. This tendon can be sacrificed without serious loss of function therefore excise the divided ends as widely as the limits of the wound will permit. As far as the tendon is concerned that concludes the operation.

2. **Severed Profundus only, severed just distal to the Insertion of the Sublimis.**—Repair of the profundus in this situation is likely to interfere with the gliding of this tendon through the slips of the sublimis (see *Fig* 1274) Therefore if suture of the profundus is undertaken, it must be combined with excision of the sublimis, with the risk that if the operation is unsuccessful, loss of flexion of the whole finger will result. The surgeon should therefore ask himself the question "Will loss of flexion of the distal phalanx be a serious handicap to the patient?" In the majority of cases the advice of Hans May should be followed Trim the ends of the divided tendon and leave them unsutured. Fix the finger for three weeks in a position of 30 of flexion of the middle interphalangeal joint

3. **Severed Profundus only severed near its Attachment.**—Within ½ in. (1 3 cm.) of its attachment to the base of the terminal phalanx is stipulated, so that the junction of the severed tendon will not by its roughness at the site of suture cause interference with free

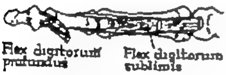

Fig. 1274.—The sublimis separates and the profundus perforates it. (*After* Testut.)

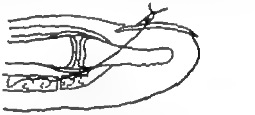

Fig. 1275 —Method of approximating a profundus tendon divided near its insertion. (*After A B. Watson*)

gliding between the two slips of the sublimis (see *Fig* 1274). The cut ends of the tendon are trimmed. *A wire suture is inserted on both sides* of the tendon *as shown in Fig* 1275 and the ends of the suture are made to emerge on either side of the finger nail. The ends of the sutures are then tied over the nail with a piece of rubber tube intervening When a tendon has united, no attempt is made to remove all the wire it is cut at skin level. Exceptionally if the wire gives rise to symptoms, it can be removed at a later date under local anæsthesia (A. B Watson)

4. **Both Tendons severed.**—There is world-wide agreement that the sublimis should be sacrificed. Therefore the sublimis is excised both proximally and distally as radically as the enlarged wound permits. This obviates adhesions between the two tendons—one potent source of curtailed function. It also results in a relatively commodious tendon sheath in which the injured profundus can swell, thus reducing the incidence of adhesion of the remaining tendon to the tendon-sheath.

It should be noted that the uniformity of opinion concerning the necessity of excising the sublimis refers only to the frequently encountered cases where both *tendons* are severed.

As to the repair of the profundus in the tendon-sheaths distal to the proximal finger crease the tendon can be sutured at the primary operation with every chance of success if the wound is a clean, incised one. Proximal to the middle palmar flexion crease primary suture is usually satisfactory The sharp differences of opinion as to whether primary suture or a delayed tendon-graft should be performed when the lesion is in no-man's-land have been discussed on p 917

5. **Flexor Pollicis Longus.**—When the tendon is divided distal to the thenar eminence (the usual situation) *primary suture is often* attended by an excellent result usually the proximal segment must be sought between the heads of the short flexor When the tendon is severed in the thenar eminence, the proximal end must be sought at the level of the wrist Pulvertaft has found that in this situation, because of tension, sutures in the distal end tend

to cut out causing fraying of the tendon. Therefore when the lesion is in this zone he recommends secondary tendon-grafting.

Results of Primary Suture of Flexor Tendons.—In the Russian series excellent results accrued in 73 per cent of the cut flexor tendons of the fingers. Taking repair of the tendon

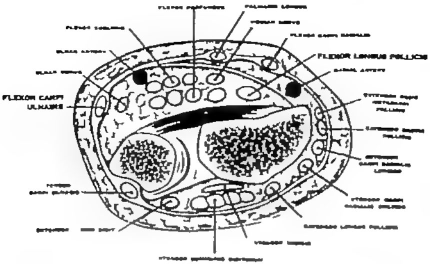

Fig. 1276.—Transverse section through the distal ends of left radius and ulna.

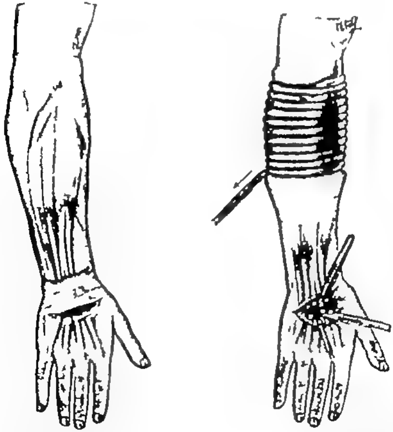

Fig. 1277.—Cut wrist. A piece of rubber tubing has been applied from above downwards in order to make the proximal ends of the tendon accessible. (*After E. W. Rockey.*)

in "no-man's-land" alone good results followed in 63 per cent of cases. Usually primary suture of the flexor pollicis longus distal to the thenar eminence is attended by excellent results.

CUT WRIST

Accidental division of tendons at the wrist is encountered frequently and seeing that secondary repair is very difficult in this situation if there is no contra indication (see p 917), primary suture is the goal

Once again the sublimis tendon or tendons can be sacrificed when the sublimis alone, or the sublimis and profundus are severed A cut palmaris longus can also be sacrificed. It is most necessary to be familiar with the anatomical arrangement of nerves and tendons around the wrist, and for refreshing the memory *Fig* 1276 is helpful When the proximal ends of either the flexor or the extensor tendons have retracted (*Fig* 1277 A) after débridement of available structures in the wound, it is most helpful to apply rubber tubing from below the elbow to the lower third of the forearm. By compressing the muscle bellies, the tubing will assist in the search for the proximal divided ends (*Fig* 1277 B). The rule for the repair of a cut wrist is to attend to blood vessels first nerves second and then proceed to unite tendons. The results of primary suture of tendons in this situation are good of 5 cases sutured with barb wire all made a perfect functional recovery (E. R Jennings)

TENDON-GRAFTING

At any rate as far as the hand and wrist are concerned at the time of a secondary operation the tendons have retracted so far that reuniting the stumps is impossible and the only means of effecting repair is by a tendon-graft. Exceptions to this rule are the profundus tendons, which in the middle of the palm are as a rule held in fairly close proximity by the attachment of the lumbricals.

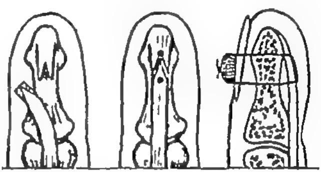
A B C

Fig 1278 —A, A A is cut in the distal end of the tendon and the distal end of the graft is cut so as to fit the A B, With the finest possible awl, two holes are made which perforate the bone to the dorsum. C, The graft is sutured to the bone by a mattress stitch, which is tied over a pad of gauze. (*After R F Bogdanov*)

Grafts that can be used are the tendon of the flexor digitorum sublimis, the tendon of the palmaris longus, and perhaps best of all the extensor tendons of the 2nd to the 5th toes inclusive. Tendon-grafting is not as difficult as might be supposed. Much patient dissection is often required to free the ends of the tendon. *A bloodless field is* maintained by the use of a pneumatic tourniquet, released for 5 minutes every 90 minutes. Good exposure is required, and in general the incisions for the hand must follow those depicted in Figs 1379 1380 p 903. For a digit the whole length of the finger or thumb is exposed by a midlateral incision. In the case of a flexor tendon of a finger most authorities advise that empty contracted portions of the tendon-sheath should be excised all emphasize the importance of preserving the narrow proximal and distal pulley like annular ligaments (digital vaginal ligaments). Should either of these ligaments have to be removed because of dense adhesions within the tendon-sheath, later in the course of the operation the pulley must be reconstructed by passing a ligamentous or fascial strip around the bone or by reconstructing the annular ligament from the residuum of the terminal crura of the sublimis tendon (Koch and Mason) The sublimis tendon is excised, as also is the distal part of the profundus to within ½ in. (1 3 cm.) of its insertion. The distal end of the profundus is found by making an incision along the proximal palmar or thenar flexion crease Then comes the tedious dissection of freeing adherent tendon in the blind area between the palmar and digital incisions. The graft is attached to the proximal stump by a Bunnell-Mayer suture The attached graft is then passed through, to emerge in the digital incision, where it is united to the distal stump (*Fig* 1278). G Pulvertaft has found that in this instance the Bunnell Mayer suture is more satisfactory than the Bunnell pull-out suture In the case of a

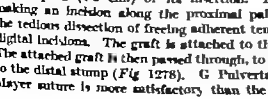

Fig. 1279 – Bunnell's method of bridging a short span with a tendon-graft.

short graft the expedient depicted in *Fig* 1279 can be employed. When each graft is fairly long, each end is attached by a Bunnell Mayer suture.

The same principles are invoked for extensor tendons, but in this instance the absence of tendon-sheath makes the operation less difficult.

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WEINSTEIN quoted by BOGDANOV (*Vide supra*.)

CHAPTER LXXX

PHLEBOTHROMBOSIS DECUBITI AND PULMONARY EMBOLISM

POSTURAL or post-operative venous thrombosis still occurs far too often. It is a serious and not infrequently a tragic, complication, for the patient succumbs to fatal pulmonary embolism. In spite of early rising and respiratory exercises, J Marks et al. have shown that the number of deaths due to pulmonary embolism has remained stationary over the past decade, and that the great majority of these deaths occur in patients in whom the diagnosis of phlebothrombosis has not been established before the fatal episode The condition must be anticipated, and it is only *awareness* on the part of the clinician that will reduce the present high incidence

Prophylactic Measures.—Precautions must be taken before during and after operation. In urgent conditions it is not often practicable for adequate instructions in breathing exercises and limb movements to be given prior to surgical intervention. In the operating theatre the calves and heels are protected from pressure on the operating table by thick layers of cotton-wool. A tight abdominal binder is avoided, unless there is a specific indication for its use. Respiratory and limb exercises should be instituted and maintained for as long as the patient is confined to bed. Such treatment should be regular and controlled, preferably by a physiotherapist. No undue immobilization is countenanced. Pillows beneath the knees are prohibited, and if Fowler s position is necessary it is maintained by one of the methods described on p. 192. Early ambulation is encouraged but with discretion. Any semblance of infection observed in the post-operative period should be treated promptly by appropriate antibiotic therapy Dehydration must be prevented or rectified. Finally it is of paramount importance that it should be regarded as a surgical sin to utilize a vein of the leg for transfusion or infusion when a vein of the arm is available. After any infusion that has been continued for more than eight hours a certain degree of perivenous cellulitis followed by thrombophlebitis is inevitable.

Diagnosis of Established Phlebothrombosis.—It is alertness on the part of the surgeon to the possibility of venous thrombosis that helps materially in the recognition of this menacing complication. Careful scrutiny of the limbs reveals many latent forms, but not all. Being very uncommon in the arms, it is to the lower extremities that attention is directed. Phlebothrombosis decubiti is rare in childhood the highest incidence occurring between 50 and 60 years of age. Moderate pyrexia, otherwise unexplained, arouses suspicion. Bearing in mind that the condition is prone to occur past the meridian of life, if the patient has undergone an operation about a week previously the well trained clinician s thoughts will turn instinctively to the lower extremities. When all those in attendance are alive to the dangers of clotting in the veins of the legs, when the nurse reports slight pain in a calf, and in relevant cases (especially between the third and seventh post-operative days) when the house surgeon undertakes routine investigations for the express purpose of detecting phlebothrombosis, then, and then only is real progress in the prevention of pulmonary embolism likely to ensue.

Have the bedclothes turned up (not down) and display the whole of the lower extremities (*Fig* 1280). Examine the limbs for swelling (which may be slight and detectable only by measurement) fullness of the superficial veins, a cyanotic tinge and palpable temperature changes.

In suspected cases proceed as follows —

1 Apply finger tip pressure over each saphenous opening, and with a stroking motion run the finger down the course of each femoral vein, seeking a segment of unilateral localized tenderness.

2. Let the patient draw up the knees and lie quietly relaxing the muscles. Commence by palpating the feet for tenderness, especially the medial aspect and behind the medial malleolus. Next squeeze the calves gently and thirdly palpate the whole of the thighs systematically the object being to seek a localized area of muscular ri[illegible] with deep tenderness.

3. Palpate deeply in the popliteal spaces, noting if there is tenderness there after which ask the patient to lower the legs on to the bed.

Fig 1280.—Diagnosis of phlebothrombosis. Display the whole of both legs and commence by applying finger tip pressure over the saphenous opening

4 Homans sign. With the knee extended, dorsiflex the foot (*Fig* 1281). Pain experienced in the calf is a positive sign of considerable significance

Fig 1281 —Eliciting Homans sign.

If as a result of this thorough investigation, the diagnosis of phlebothrombosis is reasonably assured, active therapeutic measures must be instituted forthwith. There are different lines of approach all of these having common objectives, show a commendable

tendency on the part of both physicians and surgeons to come to grips with those pressing problems—the prevention of pulmonary embolism and the avoidance of the disabling distal after-effects of widespread venous occlusion.

ANTICOAGULANT THERAPY

Before undertaking this form of treatment, facilities must exist for daily clinical supervision of the patient and full scientific determination of the effect of the drugs. The anticoagulants commonly prescribed are heparin and dicoumarol derivatives. Both are potent agents, each possessing several distinctive features.

Obviously anticoagulants should not be employed when there exists an actual or potential bleeding point, or in those blood disorders with hæmorrhagic tendencies.

Heparin acts powerfully and rapidly in preventing spread of the thrombotic process. Being non-cumulative (it is excreted rapidly by the kidneys), the action of each dose is of comparatively brief duration. Heparin is best given by the intravenous route—either continuously or by intermittent injection at relatively short periods, the effects being recorded by observing the clotting time of the blood. Sufficient heparin should be injected to maintain the clotting time between 15 and 25 minutes. If renal function is poor the dosage will have to be reduced sometimes drastically.

In the treatment of post-operative thrombosis heparinization is not likely to be followed by oozing from the incision since thrombosis is not usually recognized clinically before the wound has commenced to heal.

Dicoumarol derivatives differ from heparin in that they are effective when taken by mouth and are more slow-acting. Exerting their action by diminishing prothrombin activity their administration is governed by accurate daily estimations of the prothrombin time; the necessity for laboratory control cannot be overstated. It is to be remembered that an interval of 24–36 hours is required in which to develop full effects, and the action may be prolonged for a similar period after the last dose.

Contra indications.—Oral anticoagulants are contra indicated in hepatic disease and renal failure, as well as in states of vitamin K deficiency. They should not be given in any type of purpura, in intestinal obstruction with vomiting, or in cases of hypertension and subacute bacterial endocarditis. Other contra indications are after operations upon the central nervous system and last, but by no means least in every case where a cutting operation is contemplated in the near future. Hæmorrhage, the important complication of large and unregulated administration can become so serious as to threaten life.

Heparin Therapy.—Commercial preparations of heparin are put up in international units, but it is much more convenient to translate the dosage into milligrams. For practical purposes 100 i.u. are equivalent to 1 mg. Administration is by intermittent or continuous intravenous injection or if no vein is available, by intra muscular injection with hyaluronidase 0.1 mg. (see p. 36). If the intermittent intravenous route is used Mitchell's self retaining needle (*Fig.* 1282) will enable the nursing

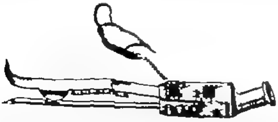

Fig. 1282.—Mitchell's self retaining self-sealing needle.

Fig. 1283.—Gordh's needle.

staff to administer the injections and obviate having to call a medical officer day and night for this purpose. Gordh's needle (*Fig.* 1283) is also convenient for withdrawing samples of blood for the determination of the clotting time.

In an average case the following dosage may have to be adjusted to keep the clotting time within the required limits.

First dose 125 mg.

Second dose 4 hours later 100 mg.

Third dose is given 4–6 hours after the second dose *only after the clotting time has been ascertained.* It will vary from 50 mg. to 100 mg., depending on the result of the test. If the clotting time is much prolonged, the third dose should be omitted altogether.

Fourth and subsequent doses are given at intervals of 4–8 hours, depending on the response of the clotting time to previous doses.

The total daily dose will usually be between 500 mg. and 800 mg.

The clotting time should be estimated daily.

Treatment should continue until the patient is completely ambulant and has been free of pain and pulmonary embolism for 7–10 days.

Oral Anti-coagulant Therapy.—A veritable host of dicoumarol derivatives are now available, and the later preparations are much safer than the original ones. Their chief indications are in relatively mild cases of phlebothrombosis which have been diagnosed early (as they should be) and in combined oral and intravenous anticoagulant therapy (*see below*). The chief disadvantage of anticoagulants administered orally is that dosage has to be based on daily prothrombin time estimations, which require laboratory facilities. In the absence of full laboratory facilities *oral* anticoagulants should not be given because their actions are erratic, and consequently bleeding from the area of operation may ensue.

At the time of writing the cheapest and best oral anticoagulant is phenylindanedione (dindevan), and treatment with this drug will be described. If another preparation is used the dosage can be ascertained by perusal of the manufacturer's instructions, but the principles are identical.

First dose 200 mg. (of dindevan).

Second dose after 12 hours, 100 mg.

Subsequent doses 50–100 mg. 12 hourly with the object of keeping the prothrombin time between 20–30 per cent of the normal time for the particular patient as estimated by the particular laboratory. Daily estimations should be performed.

Treatment is continued until the patient is completely ambulant and has been free from pain and pulmonary embolism for 7–10 days.

Combined Anticoagulant Therapy.—In practice (except in mild cases) heparin and oral anticoagulant therapy are started simultaneously and the former is discontinued after 24–30 hours when the prothrombin time has been reduced to the requisite level.

Specific Antidotes.—In certain circumstances it becomes imperative to counteract the action of the anticoagulant drugs. In the case of *heparin* this can be effected in a few minutes by the intravenous injection of 5–10 ml. of a 1 per cent solution of protamine sulphate. If this drug is not available one of the protamine zinc insulin preparations should be utilized (with the administration of sufficient dextrose to counteract the hypoglycæmic action of the insulin).

On the other hand, the action of the *dicoumarol derivatives* is not so easily and rapidly reversed, and it takes several hours and occasionally even days to neutralize the anticoagulant effect of these drugs. Vitamin K_1 (20–30 mg.) should be given intravenously; when this proves unsuccessful in restoring the prothrombin time to normal a transfusion of fresh blood should be given.

Complications of Anticoagulant Therapy.—Slight hæmaturia, mild epistaxis, and even considerable bruising, are not causes for alarm; they are the hall-marks of adequate therapy.

When hæmatoma formation, severe hæmaturia, considerable epistaxis, or hæmothorax occur the dosage of the anticoagulant drug used should be decreased. If blood loss proves serious the specific antidotes should be given, and in necessary cases blood transfusion should be commenced without delay. Occasionally febrile and anaphylactic[1] reactions occur with these drugs, and indicate the necessity for a change to an alternative preparation.

Bleeding from an unrelated condition such as a duodenal ulcer introduces a problem in priority. In this particular instance sometimes it is wise to abandon anticoagulant therapy in favour of proximal venous ligation (*see below*). On the other hand, when the bleeding can be controlled comparatively easily by a direct attack (e.g. a vesical papilloma or a rectal polyp) this is obviously the course to follow and as soon as the bleeding has ceased anticoagulant therapy can be resumed. Each case must be dealt with strictly on its merits.

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[1] Anaphylaxis following the administration of heparin (*see* p. 79).

Additional Treatment.—As it is impossible to state where aseptic phlebothrombosis ends and infected thrombophlebitis begins it is logical to treat all these cases as being infected.

The affected leg should be supported by firm crêpe bandaging extending from the toes to the groins, after the application of a kaolin poultice over the painful segment of the vein. Antibiotic therapy is also indicated and unless there is good reason to prescribe another penicillin 500 000 units 12 hourly is administered

PROXIMAL VENOUS LIGATION

The wave of enthusiasm for vein interruption in the prevention and treatment of pulmonary embolism has receded The reasons for this are fourfold —

1. As Ian Aird has emphasized an embolus originates more frequently from a clinically silent area of phlebothrombosis, rather than from an easily apparent patch of thrombophlebitis.

2. Moreover this silent phlebothrombosis may be situated in the pelvic veins so it comes about that the only effective vein interruption is that of the inferior vena cava.

3. The operation of ligation of the inferior vena cava has been shown to have severe late sequelæ. In Shea and Robertson s series of 25 patients, 24 had bilateral œdema of the ankles after the operation, 10 had leg ulceration, 9 were unable to carry out their previous occupations, and only 1 was entirely free from after-effects.

4. Ligation of the inferior vena cava is a formidable procedure especially in a patient who has very recently suffered a severe pulmonary embolism and there have been numerous unrecorded fatalities.

INDICATIONS FOR LIGATION OF THE INFERIOR VENA CAVA

1 Occasionally when phlebothrombosis is known to exist at the time of the primary operation.

2. Likewise there are rare occasions when the patient has suffered pulmonary embolism during the pre-operative period.

3. The occurrence of repeated emboli while the patient is under going anticoagulant therapy Al though no one can foretell whether small emboli causing no more than transient pain in the chest are not harbingers of a larger embolus, in a given case it may be justifiable to continue with expectant treatment In such cases, however it is essential to review the dosage of anti coagulants it is possible that the cause of the repeated emboli is inadequate dosage. It should be remembered that anticoagulants can be continued with safety for many weeks, and even months.

4 Caution must be exercised before undertaking ligation of the inferior vena cava in patients with carcinoma. The extensive deep thrombosis of malignant states has been stressed since the teachings of Trousseau. Less widely known, however is the fact that thrombotic disease in carcinomatous subjects is prone to be of the migrating type. Therefore, careful examination of all four limbs, and even of the neck, should precede the decision to ligate the inferior vena cava.

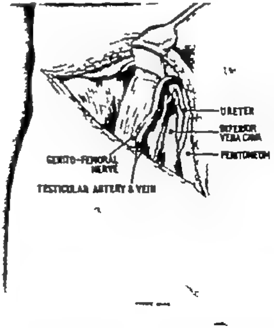

Fig 1284 —The approach to the inferior vena cava utilizing Morison incision.

Technique of Ligation of the Inferior Vena Cava.—Anticoagulant therapy should be stopped and the particular specific antidote (*see* p. 928) administered.

CHAPTER LXXXI

URGENT SURGERY OF BLOOD VESSELS

The immediate treatment of a wound of any large artery is to apply pressure to the bleeding point with the left thumb while the right hand seeks the point of vantage to compress the artery above the wound. In the case of the limbs, when the wound is below the axilla or groin, direct compression is quickly changed in favour of some form of tourniquet. Unfortunately for the patient, it is seldom that skilled help can be procured on the scene of the accident. Thus it comes about that the general diffusion of first-aid knowledge among the public is to be encouraged. Sometimes it happens that a little knowledge is a dangerous thing:—

A man was admitted dying from hæmorrhage from a wound in the thigh. Before his transit from an outlying district to hospital, a tourniquet had been applied ineffectively above the wound. The femoral artery was intact, but there was a large opening into the femoral vein.

Firm local pressure usually arrests bleeding. When the pressure is removed a fleeting opportunity is afforded to view the source of the hæmorrhage. Often it is found that it is not the main artery that is bleeding, but a large branch thereof (S. M. Cohen).

Temporary arterial constriction should not last longer than half an hour; by that time it must be followed by one of the measures to be detailed in this chapter. If facilities are not available for proper exploration of the wound the medical practitioner must secure the bleeding point temporarily, using whatever means are available. This accomplished the tourniquet is removed.

On the other hand, the emergency surgeon should do all within his power to avoid ligation of critical arteries (axillary, brachial, iliac, femoral, popliteal). H. H. Ziperman found that in the Korean War the proportion of extremities lost, when compared with the results obtained in the Second World War, was reduced from 40 per cent (de Bakey and Simeone) to 20 per cent, by the greater use of conservative operation.

VASCULAR SUTURE

Suture of a wounded blood vessel is not as difficult as is sometimes assumed. Results in properly selected cases are superior to those of ligation. In the case of a large vein, contrary to what might be thought, sutures hold well. The inferior vena cava and common iliac vein have often been repaired successfully after accidental injury in the course of a surgical operation.

Arterial suture is called for when there has been little or no loss of the arterial wall. Stab wounds involving a vessel often fulfil this criterion. On the other hand, if there has been loss of substance of the vessel wall suture is liable to be followed by such narrowing that thrombosis ensues. Consequently, one of the methods of restoring the continuity of the artery described below should be utilized.

Methods of Temporarily Occluding an Artery.—Before an artery can be sutured it is necessary to occlude it temporarily. The following methods are in use:—

1. *Sol Cohen's Method.*—A strip of corrugated rubber is passed around the artery and held moderately taut by the assistant (*see Figs.* 1287, 1307).
2. *Sir Charles Gordon Watson's Method* (*Fig.* 1285).—The tape should be soaked in paraffin, otherwise it knots jerkily and is liable to damage the artery.
3. *Crile's Arterial Clamp* (*Fig.* 1286).
4. *Blalock's Arterial Clamp* (*see Fig.* 1288).

In the absence of special arterial clamps Method 1 will be found most generally useful. Method 2 is particularly valuable when assistance is limited.

Suture Material.—No. 100 cotton, No. 000 untwisted Chinese silk, or the finest linen thread; the finest round bodied needle compatible with the suture material. After sterilizing, lightly anoint the suture with sterile liquid paraffin. Special atraumatic arterial sutures (size 00000) are valuable, if available.

Provision must be made to prevent clotting The wound is moistened with isotonic sodium citrate solution or ½ per cent heparin.

Instruments.—Fine instruments are preferable for vascular surgery In an emergency the ophthalmic surgeon s instruments will be found to provide the fine mosquito hæmostats and dissecting forceps necessary Special arterial clamps (Crile s or Blalock s) are useful,

Fig 1285 —Temporary occlusion of a large artery by Gordon-Watson method. A, Rubber drainage tube ; B, Tape tied with a single turn.

Fig 1286.—Crile s arterial clamp forceps.

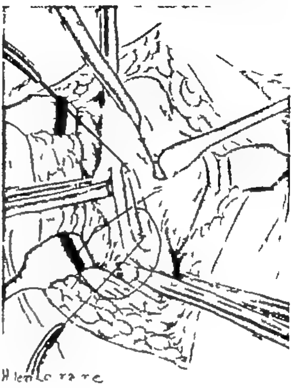

Fig 1287 —Wound of the femoral artery being repaired by suture

but not essential. Lahey s swabs (*see Fig* 12) and Desjardins forceps (*see Fig* 1303) are also of great value

Technique of Suture—The edges of the wound in the vessel should be cleared of adventitia but no attempt should be made to excise them. A continuous over and-over stitch as shown in *Fig* 1287 can be utilized, and will give excellent results. Interrupted mattress sutures (*see Fig* 1280) produce better eversion, and are an added refinement Another method is a continuous mattress suture, but there is little to choose in the results of all three methods.

When the clamps are released there may be a little leakage at one or two points, necessitating additional interrupted sutures.

END-TO-END ARTERIAL ANASTOMOSIS

Thi is the method of choice when a vessel has been divided completely or when a lateral wound has caused uch los of substance that simple suture would be followed by narrowing Its use is, of necessity limited to the loss of a relatively short segment but it is permissible to mobilize the damaged vessel extensively (provided no large branch is sacrificed). At the same time it must be known that in an. nod vessels moderate tension is an advantage It is also permissible to flex a l the vessel ends to be brought together

Temporary c lled as before e arteries are trimmed any excess of adventitia as This is fo ation of t ior of the end of the vessel heparin (see tas passed at equidistant point are pulled t forme). The

portions A–B, B–C, and C–A shown in the inset are sewn separately using a mattress suture to evert the edges (*Fig* 1289) This eversion forms an ideal junction, endothelium being apposed accurately to endothelium. Particularly with a small vessel, it is often an advantage to employ only two stay sutures. When the anastomosis is completed the stay sutures are removed

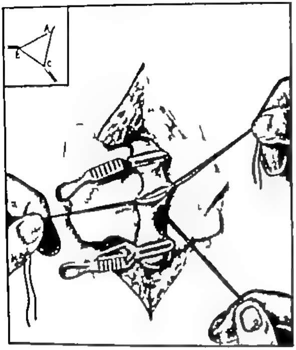

Fig. 1288.—End to-end arterial suture Three stay-sutures have been inserted Blalock's clamps are being used.

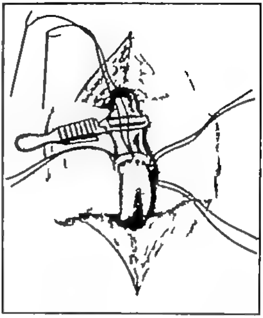

Fig 1289 —End-to-end arterial suture The edges of the artery have been approximated by mattress sutures.

ARTERIAL GRAFTING

Various methods of arterial grafting used in the treatment of obliterative arterial disease have led to a decrease in the amputation rate (*see* Ziperman s statistics, p 931). In average hospital practice, and certainly under the conditions of warfare the use of preserved arterial homografts, as popularized by Rob and Eastcott at St. Mary s Hospital London is not practicable. During the Korean War it was found that, for lesions of the critical arteries (axillary brachial, iliac, femoral, popliteal) autogenous vein grafts were as good, and probably better The long saphenous, external jugular or cephalic veins can be used and it is important to remember to reverse the vein in order to avoid obstruction to the flow of blood by any valves present. As an alternative, various impervious plastics such as orlon, nylon, and vinyon N can be used in an emergency and a number of workers have shown that a process of arteriogenesis occurs, new fibrous tissue being laid down on the foundation of the plastic cloth tube which acquires an endothelial lining

Fig 1290.—1 Polyvinyl graft; 2, Orion graft.

Any one of a number of plastic cloths can be utilized, and in an emergency a piece of close-mesh nylon cut from a shirt or other article of clothing can be employed. For a femoral arterial prosthesis two pieces of material 1 in. (2 5 cm.) wide are laid on one another and stitched together with two rows of stitches, using a sewing machine, and giving a diameter of ½ in. (*Fig* 1290). The prosthesis can be sterilized by boiling and when used the correct length is calculated and the ends are everted to provide smooth edges for

anastomosis with the artery After the clamps are released there is always a certain amount of leakage of blood, but this ceases as the blood clots in the interstices of the material.

Recently a new plastic material—polyvinyl-ester sponge[1]—has become available Introduced by N. E. Shumway et al., thin strips of the material are wrapped around a glass rod the size of the vessel to be replaced, and held in position by an ordinary roller bandage When sterilized by boiling, the material fuses and becomes flattened and as smooth as the glass on its inner surface and on cooling down can be made to slide off the mould as a resilient but tough graft which closely resembles an actual artery In the future it is likely that this material will be easily obtainable.

Technical Points in Arterial Grafting.—

1 A time lag of up to 15 hours will not vitiate success, and the procedure should be attempted even later than this, as the collateral circulation may have kept the limb alive Nevertheless, the earlier the operation the better the prognosis.

2. *Wound débridement (see Chapter XIII) should be carried out first, and the classical* approaches described in Chapter LXXXII should then be utilized for adequate exposure of the particular artery damaged. In many cases it will be found that the débridement of the wound, with slight extensions, will provide adequate exposure.

3. Jahnke and Seeley have shown that microscopical damage to the arterial wall extends much farther than the apparent macroscopic damage. With the object of preventing subsequent thrombosis due to this *occult trauma, a centimetre of each end* of the artery should be excised beyond the point of gross damage; once a decision has been reached to use an arterial graft the loss of a further 2 cm. makes no difference.

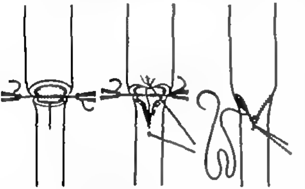

Fig 1291 —Method of anastomosis when there is a discrepancy in size between the artery and the graft. (*After E. Holman.*)

4 When arterial clamps have been *applied proximal and distal to the* divided ends of the artery a few ml. of ½ per cent heparin should be injected with a fine hypodermic needle beyond the clamps, to minimize the possibility of thrombosis.

5. If there is a discrepancy between the sizes of the artery and the graft the expedient suggested by E. Holman should be used (*Fig* 1291)

6. The technique of anastomosis is the same as that described under ARTERIAL ANASTOMOSIS (see p 932)

7 *The grafts should be sewn in under slight tension, otherwise they tend to kink*, and later thrombosis occurs.

8. It is convenient to complete the proximal anastomosis first and then release the proximal clamp and seal off any leaks with interrupted sutures. The proximal clamp is then reapplied and the distal anastomosis completed in the same way

9 The anastomosis and grafts should be covered by muscle or fascia if possible before skin closure Should a rotation flap prove necessary for skin closure the resultant skin defect should be covered by split-skin grafts.

10. Anticoagulant therapy is contra-indicated, as bleeding from the anastomosis would result.

LIGATION

Ligation can be employed without hesitation in the case of the smaller arteries, but its use should be a last resort when interruption of the vessel concerned would carry an appreciable risk of gangrene (*Fig* 1292). It follows that its application in injuries of critical arteries should be entertained only if circumstances dictate that the methods just described cannot be applied. Catgut should not be employed as ligature material for any artery of *appreciable size A non-absorbable suture (silk, cotton) carries a greatly* decreased risk

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[1] Ramer Chemical Co., 79 Blackheath Hill, London, S.E.10.

of secondary hemorrhage. Should the wound become even mildly infected, catgut becomes prematurely digested.

The stay-knot of Ballance is useful in the case of large arteries. Two independent ligatures are placed very close to each other. The first tie concerns each ligature only; the second is made with both ligatures taken together. *Fig.* 1293 makes this procedure clear.

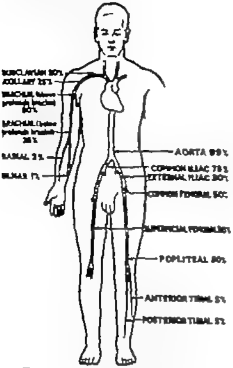

Fig. 1292.—The expectation of gangrene following ligation of a main artery after injury. Based on Heidrich's (World War I) and de Bakey and Simeone's (World War II) statistics.

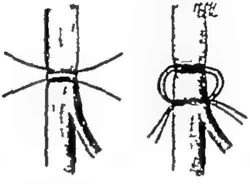

Fig. 1293.—Ballance's stay knot.

The application of a ligature that controls what would quickly prove fatal hemorrhage rightly engenders a sense of satisfaction. Nevertheless, simple ligation must not content the surgeon. The artery should be *divided* between ligatures. The reasons for this injunction are well founded. In the first place ligation in continuity is far more likely to be followed by secondary hemorrhage than division between ligatures. The kicking arterial stump of an artery ligated in continuity cannot retract, consequently the constriction of the ligature causes pressure necrosis because the weakest point is subjected to constant battering (*Fig.* 1294 A). When an artery has been divided between ligatures the stump *is mobile* and retracts; therefore, the force of pulsation is dissipated (*Fig.* 1294 B).

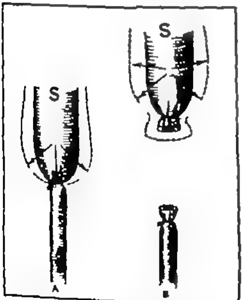

Fig. 1294.—A, Simple ligation. The kicking arterial stump cannot retract. Consequently the force of pulsation is centred on that weakened rim of arterial wall constricted by the ligature. Secondary hemorrhage invited. B, Division of artery between ligatures. Kicking stump retracts and thus the force of pulsations is dissipated. Secondary hemorrhage is highly improbable. (*After Emile Holman.*)

Fig. 1295.—Closing the open mouth of an artery by suture, to avoid ligating two main branches. (Maybury's expedient.)

Another important dictum is to ligate an artery as near as possible to the lesion.

Minimizing the Risk of Gangrene.—The following measures have proved helpful:—

Removal of Clot from the Distal End of the Artery.—Before applying the ligature to the distal end of the divided artery the hæmostat should be loosened. If no bleeding occurs, an attempt should be made to clear the interior of the artery of clot. Clot within the lumen of the artery may jeopardize the establishment of a satisfactory collateral circulation.

Closure of the Distal End of the Artery by Suture.—Gangrene is especially liable to follow occlusion between ligatures of an artery just above its bifurcation into two main branches, e.g. the brachial artery in the antecubital fossa, the common femoral just above where it divides into the superficial femoral and the profunda femoris. Ischæmia and gangrene can sometimes be circumvented by adopting the expedient of Maybury. Instead of ligating the dividing limbs of the artery the open end of the arterial fork is closed with a running suture (*Fig.* 1293).

Ligation of the Corresponding Vein.—H. H. Ziperman's conclusions (based on Korean War results) are that this measure is contra-indicated.

Gangrene Inevitable.—Usually there is no reason to hurry to amputate the limb. Treatment as for dry gangrene should be instituted. When the time comes for the operation, refrigeration anæsthesia (*see* p. 968) has much to recommend it in a frail patient.

POST-TRAUMATIC VASCULAR INSUFFICIENCY (VOLKMANN'S ISCHÆMIA)

Volkmann's ischæmia following a closed injury of an extremity may be due to a number of conditions:—

1. Injury to a major artery by a bone fragment.
2. Spasm of a major artery due to trauma.
3. Disruption of arterial muscular branches at the time of injury.
4. Occlusion of arterial branches by local pressure due to a tight plaster-of-Paris cast or bandage.
5. Occlusion of arterial branches by a hæmatoma enlarging beneath the unyielding deep fascia.

It must be appreciated that the blood pressure in muscular arteries and vasa nervorum is only about half that in the major arteries so that the presence of a radial pulse, for example, does not imply that the muscles and nerves of that arm are receiving an adequate blood-supply. Therefore, after an injury to a limb followed by pain in the hand or foot, the early signs of Volkmann's ischæmia should be sought assiduously: they include pallor or cyanosis, œdema and weakness or paralysis. Pain on passive extension of the fingers is particularly significant. Pulses are not necessarily absent, but if present, are often weaker on the affected side.

Treatment.—The first step is to release a tight plaster or bandage, and if the fracture is near the elbow or the knee, the limb should be extended. Adequate reduction of a fracture is required if radiographs suggest that a bone-end is impingeing on the brachial or popliteal artery.

When the above-mentioned measures fail to provide rapid relief, in the case of an arm the next step is the induction of a brachial-plexus block. The aim of this is twofold: firstly, the relief of spasm by cervical sympathetic block, and secondly, to provide anæsthesia should operation prove necessary.

Brachial Plexus Anæsthesia.—The patient lies with the head and neck on a pillow and with the head rotated to the opposite side. In order to depress the clavicle, an assistant exerts traction on the arm at the patient's side, provided the causal injury permits this step. The index finger palpates the subclavian artery above the middle of the clavicle and with this finger depressing the artery a skin weal is raised immediately above the finger-tip (½ in. (1·3 cm.) above the clavicle). A fine spinal needle is then passed in the direction of the spinous process of the third thoracic vertebra (downwards, inwards, and backwards). As the needle is inserted it may strike part of the brachial plexus, and cause pain in the arm. This should be the signal for commencing the injection of the local anæsthetic. Alternatively, the needle may reach the first rib at a maximum depth of 2 in. (5 cm.) without causing pain, and injection should then start at this level. In either case, after aspiration of the needle to make certain that it is not in a blood vessel or the pleura, 40–50 ml. of 1 per cent procaine is injected slowly, the needle being withdrawn gradually while the injection is in progress.

The last resort if there is still doubt about the circulation is exploration of the affected artery This is carried out conveniently under the previously induced brachial-plexus block, supplemented if necessary by local anæsthesia

Arterial Exploration for Volkmann s Ischæmia.—The particular artery (usually the brachial) is approached as detailed in Chapter LXXXII After incision of the deep fascia a hæmatoma, if present is evacuated. Examples of tense subfascial hæmatomata being the sole obstructing agent have been reported. A hæmatoma within the arterial sheath should be evacuated. J B. Kinmonth has found that the local application of a 2 5 per cent solution of papaverine sulphate for several minutes is most effective in relaxing spasm If this measure fails, a periarterial sympathectomy should be performed In the rare event of a tear of the main artery being found the continuity of the vessel must be re-established

Sometimes a segment of artery is found to be thrombosed (W S. Edwards) and in this event the artery should be opened and the clot removed (see TECHNIQUE of EMBOLECTOMY p 941) In late cases excision of the thrombosed segment followed by an arterial graft, may be required.

ACCIDENTAL INTRA ARTERIAL INJECTION OF DRUGS

As S. M. Cohen remarks in his valuable study of thiopentone cases, this accident can happen to anyone. Contrary to what is usually taught, puncture of the arterial wall is usually painless, but an intra-arterial injection of thiopentone causes severe agonizing pain coming on when about 2 ml has been injected. Intense transient vasoconstriction usually follows and several of the cases analysed by Cohen showed, besides involvement of the hand and fingers, mottled bluish-green patches in the skin of the forearm, around the elbow joint and in the arm well above the site of injection A striking feature in some patients was extensive œdema of the hand and forearm this may be evident within 2 hours and well marked within 5 hours. Massive gangrene of the limb followed extensive thrombosis in the major vessels. The commonest abnormality predisposing to the accident is a superficial ulnar artery (*Fig* 1296)

Fig 1296 — Veins distended with a rubber band. Arrow indicates superficial ulnar artery. Gliding of the needle to enter the median basilic vein may lead to puncture of the artery (*S M Cohen.*) (*By kind permission of The Lancet*)

When this accident occurs the needle should be left in situ and 10 ml. of 1 per cent procaine injected into the artery in an effort to release vasoconstriction. Provided the circulation in the limb is quite satisfactory after this measure (it is frequently effective), the operation is carried out as planned. On the other hand, if there is any sign of impaired circulation in the affected limb the operation, unless imperative, should be postponed and immediate heparinization (see p. 927) carried out, provided there are no fractures present from which bleeding would occur

If after 4–6 hours the circulation has not returned to the arm the operative measures detailed under Volkmann s ischæmia (see p. 936) are indicated.

ARTERIAL OCCLUSION BY AN EMBOLUS

The restoration of the circulation by the removal of an embolus was a notable advance in urgent surgery However during the past few years, with the development of anticoagulant therapy there has been a gradual narrowing of its indications (see p 939) In England the possibilities and urgency of treatment are not yet fully appreciated (*Fig* 1297)

Usually an embolus lodges where an artery divides. The bifurcations of the aorta, common iliac, femoral, and the popliteal arteries are favourite sites (*Fig* 1298). In the upper limb, embolism is relatively uncommon The axillary artery at the point where its subscapular branch is given off and the brachial artery at its bifurcation, are the usual sites of arrest (*Fig* 1299).

Diagnosis and Localization of the Site of the Embolus.—Localization of the site of the embolus is more difficult than the diagnosis of its presence. Suddenly there is cramp in the limb The pain may be severe, but more often it is less than one would expect, the patient s main complaint being numbness and loss of use of the member

On Examination.—The limb is blanched and paralysed, and below the occlusion pulsations have ceased. Here the prick of a needle fails to bleed. Proximal to the embolus the artery is beating as in an amputation stump; below it is empty, contracted, and still.

Fig. 1297.—Too late to save the limb! An embolus became lodged in the common femoral artery forty-eight hours before the patient's admission to hospital. The patient was a young woman with mitral stenosis.

When pain is present, unfortunately the site of maximum pain is not necessarily the site of the embolus; *for instance, when an embolus is arrested at the bifurcation of the femoral artery* symptoms are often referred to the knee. The collateral circulation also helps to beguile us. What we need in cases of doubt is quick, definite proof of the exact location of the embolus. In the absence of the facilities for arteriography the following test may prove helpful.

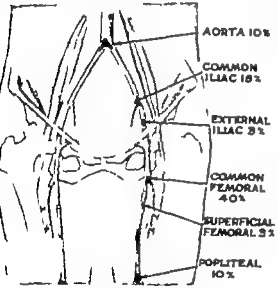

Fig. 1298.—Location of peripheral emboli in the lower extremity.

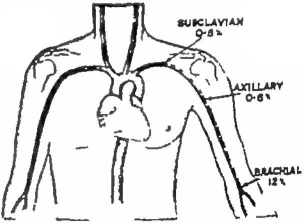

Fig. 1299.—Location of peripheral emboli in the upper extremity.

(Figs. 1298, 1299 founded on 833 cases collected by R. E. Pearse.)

The Auscultatory Test: Temporarily occlude the femoral (or brachial) artery at the root of the limb with the pressure of a sphygmomanometer cuff. Alternatively, instruct an assistant to compress the artery with his thumb. A stethoscope is applied at various points along the *course of the artery from above downwards. After releasing pressure the booming* of the returning arterial flow will be heard until the site of the embolus is reached, when there is an abrupt cessation of sound (R. J. Last).

Percutaneous Disimpaction of the Embolus (S. M. Cohen) is a valuable measure if the clot lies in an artery which is relatively superficial. In suitable cases this should be attempted as soon as the patient has been heparinized. The artery is palpated carefully for the site of arrest of pulsation, and is then gently but firmly massaged from above downwards. The

vessel may be felt to leap into pulsation as the clot glides onwards to become arrested distally in a less important part of the artery or in one of its branches.

Embolism of the Upper Limb.—If the embolus has lodged in the upper limb further diagnostic refinement is a matter of interest only as the correct treatment is heparinization (see p. 927) which should be immediate high doses being used. With this régime it is rarely if ever necessary to resort to embolectomy but the limb should be watched carefully for the first 6–8 hours. Morphine is administered and warming of the limb avoided.

Mrs. M. A., aged 68, was admitted having experienced transient lower abdominal pain three days previously This was followed by coldness, blueness and paralysis of both legs, and it was obvious that an aortic saddle embolus had disintegrated, the fragments lodging in the femoral arteries, probably at the profunda femoris origin. The lower limbs were gangrenous and beyond hope. Her general practitioner had requested admission because some 12 hours previously the

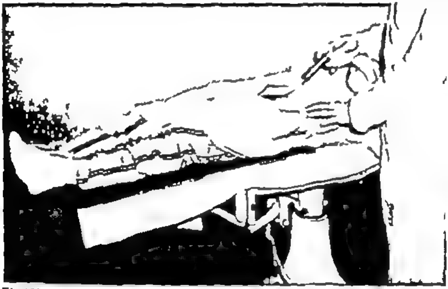

Fig. 1300.—Method of percutaneous femoral arteriography if a special limb-length cassette is available

right lower arm had become weak and cold! The right radial pulse was absent, and the hand was cold and blue from the mid-palm distally The cause of the embolism was auricular fibrillation.

Heparinization was followed in a few hours by return of normal colour and movements to the right hand. The patient refused amputation of the lower limbs, and died three days later Post-mortem examination confirmed the sites of lodgement of the emboli, which had been postulated.

Embolism of the Lower Limb.—When an embolus is arrested below the bifurcation of the aorta the interests of the patient are best served by varying the treatment in accordance with the length of time that has elapsed since the time of lodgement.

Indications for Heparinization and for Embolectomy—

1. **Early Cases** (those of up to 8 hours duration).—Six to eight hours after lodgement of the embolus can be spent in endeavouring to restore the circulation by means of heparin (see p. 927). If, after this period, the colour of the affected limb remains unchanged and the temperature unaltered, embolectomy is called for While the operating theatre is being prepared and the necessary instruments assembled, the specific antidote (see p 928) is administered.

2. **Intermediate Cases** (8–16 hours duration)—Embolectomy without delay offers the patient the best chance of saving the limb

3. **Late Cases** (over 16 hours duration)—By this time probably irreversible thrombosis has occurred in the arterial wall distal to the embolus, and in a very high percentage of cases gangrene of at least a part of the limb is inevitable. A futile attempt at embolectomy only decreases the chance of saving at least part of the limb, as heparinization must be postponed for at least 12 hours after operation, because of the risk of hemorrhage.

These patients, many of whom are poor surgical risks because of auricular fibrillation, and prone to further showers of emboli are best treated by heparinization while awaiting a line of demarcation. Before amputation the specific antidote must be administered.

Five hours after its lodgement an embolus was removed successfully from the common femoral artery of a woman of 62 suffering from auricular fibrillation. An attempt at post-operative heparinization led to bleeding and was discontinued. Two days later she died of a cerebral embolus. In retrospect her chances would have been better with immediate heparinization.

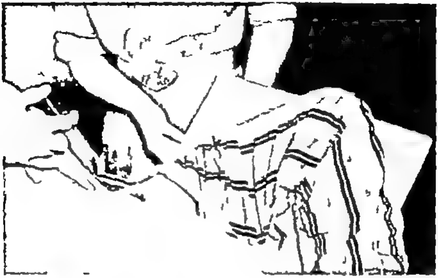

Fig. 1301.—Method of utilizing 17 × 14 in. (42.5 × 35 cm.) cassette.

Fig. 1302.—Showing complete occlusion of an arteriosclerotic femoral artery in the lower third of the thigh. Note calcification in the walls of the unobstructed segment.

Fig. 1303.—The field of operation ready for removal of an embolus from the femoral artery.

Once a decision to operate is reached there may be some doubt as to the exact site of the embolus.

Femoral Arteriography is often a useful preliminary to operation if the common femoral artery is pulsating, showing that the embolus has impacted distally. The X-ray films are placed as shown in *Figs.* 1300 and 1301. Of 35 per cent diodone (or a similar opaque

medium) 18 ml is drawn up into a 20-ml syringe and with a large-bore angled needle the *femoral artery* is entered obliquely percutaneously. There will be no doubt when the artery is punctured: blood will spurt back into the syringe forcibly. The medium is injected as rapidly as possible and the radiograph taken when 15 ml have been introduced. On withdrawing the needle, while the film is being developed, firm pressure with gauze at the site of puncture prevents leakage of blood. The site of obstruction being thus displayed pictorially (*Fig* 1302), the operation is planned according to radiological findings.

If difficulty is experienced with the percutaneous method, a vertical incision just below the inguinal ligament will enable arteriography to be carried out under direct vision and in many cases the incision, if prolonged, can be utilized for the subsequent embolectomy.

Armamentarium.—Suture materials and instruments, as described under VASCULAR SUTURE (see p. 931), are necessary.

If a sucker is available a Eustachian catheter fitted to its tubing, or a glass tube of similar calibre with a blunt end, is most desirable. In the absence of a sucker one of the foregoing end pieces connected by a piece of rubber tubing to a well fitting syringe allows clot to be sucked out of the artery.

Anæsthesia.—As a general rule the operation should be performed under local anæsthesia. In a number of reported successful cases spinal anæsthesia has been used. Vasodilatation following a spinal anæsthetic sometimes results in the embolus passing distally (R. Daley). For this reason, after administering a spinal anæsthetic it is prudent to wait for a quarter of an hour and then to reassess the level of pulsation before commencing the operation.

Technique of Embolectomy.—Often the embolus is situated in the common femoral or in the superficial femoral artery, either of which can be approached through the femoral triangle (see p. 931). Less frequently an incision will be required above the inguinal ligament for access to the common or external iliac arteries (see p. 930) or in the popliteal fossa for removal of an embolus at the popliteal bifurcation (see p. 932). Careful clinical examination of the pulses, together with arteriography in doubtful cases, should enable the surgeon to site his incision correctly.

Exposing the Common Femoral Artery.—Procaine solution is injected into the skin in the line of the artery and an ample incision is made downwards from the inguinal ligament, bearing in mind that the origin of the profunda femoris is more distal than one is inclined to imagine. More procaine solution is injected, and by suitable dissection and retraction the artery is displayed. If the diagnosis is correct and that part of the artery containing the embolus is under vision, the artery will be found to be in spasm but slightly swollen and darker in colour in the region of the embolus (*Fig* 1303).

Before proceeding further, arterial clamps or slings are placed in the positions shown in *Fig* 1303, in order to prevent migration of the embolus and to control hæmorrhage.

Separation of the Adventitia.—A longitudinal incision is made through the adventitia about ¾ in. (2 cm.) long and each edge of the adventitia is grasped in a hæmostat. Using a Watson-Cheyne dissector or a Lahey's swab (*see Fig* 12) the adventitia is separated from the media (*Fig* 1304). This step facilitates subsequent arterial suture.

Opening the Artery.—The wound is moistened with sodium citrate solution.

The best site for extraction of the embolus is at the origin of the profunda femoris artery, as often a part of the embolus is in this important branch and cannot be removed except under direct vision. The artery is incised longitudinally; the opening should be small in the first instance (½ in.).

Extraction of the Embolus.—Sometimes the clot is extruded spontaneously, or some of it remains to be picked out with a Desjardins gall-stone forceps (*Fig* 1305). It is important to remove as much clot as possible from the distal portion of the artery before traction to the distal sling, or an arterial clamp is re-applied. When the distal part of the artery is freed from clot, some bleeding from it is observed with pleasure. When no more clot can be extracted traction is re-exerted to the distal sling. With due caution, tension on the proximal sling is momentarily released. If blood spurts we have achieved our objective of clearing the lumen of clot. All slings are kept tight until the artery is sutured. If a free flow of blood is not obtained from both the proximal and the distal ends of the artery further clot must be sought. Suction (*Fig* 1306) is of value in evacuating distant clot but great care must be exercised lest the intima be further damaged and late thrombosis results.

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Closing the Artery —An interrupted suture is inserted at each extreme end of the incision—these sutures are held by the assistant while the incision in the artery is closed. If the arterial wall is elastic a running suture can be used (*Fig* 1307) Only if the suture

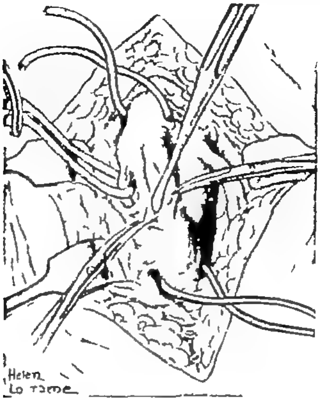

Fig 130[illegible] —Separating the adventitia over the area of the proposed line of incision in the artery

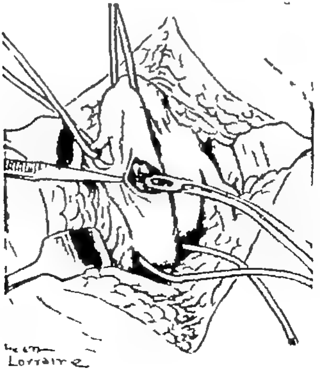

Fig. 130[illegible] —Extracting the clot

line proves sound are the slings removed It may be necessary to reinforce the line of suture with an interrupted stitch or two The adventitia is left unsutured

When the circulation has been restored the blanched toes assume a pink hue and a few minutes later hyperæmia of the limb is evident.

E. L., aged 40, a patient in a medical ward experienced cramp in his left leg at 1 40 p m. At 1.50 p.m. there was severe pain in the limb. The house physician was summoned and found the leg pale and cold below the knee He diagnosed popliteal embolism. Further examination showed that no pulsation could be felt in the femoral artery At 3.45 p.m., under local analgesia the common femoral artery was exposed Above the origin of the profunda the artery was full and pulsating Below the bifurcation both the profunda and the femoral arteries were empty and pulseless. The artery was opened in the manner described on p 941 There was a three-limbed clot (*Fig* 1308) situated at the bifurcation. The profunda clot and the lower femoral clot extruded themselves spontaneously these vessels then bled slightly but

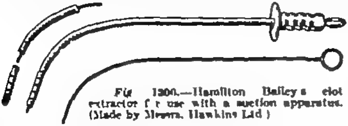

Fig 1306.—Hamilton Bailey's clot extractor for use with a suction apparatus. (Made by Messrs. Hawkins Ltd)

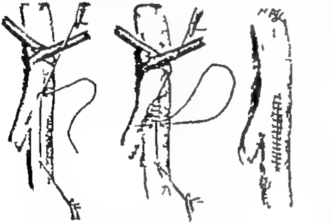

Fig 1307 —Closing the incision in the artery

Fig 1308. —The embolus removed from the bifurcation of the femoral artery in the case of E.L. consisted of three fragments, one in the main trunk and one in each of the branches.

without pulsation. The proximal femoral clot was withdrawn with Desjardins's forceps. This was followed by a gush of blood, controlled at will by the sling The incision in the artery was closed. The suture line was reinforced in two places by an interrupted stitch. Hæmostasis proved satisfactory The distal femoral artery and the profunda remained contracted but pulsated. The wound was closed. The patient recovered.

FAILED LOWER LIMB EMBOLECTOMY

The usual cause of failure is that the operation has been attempted too late and thrombosis has occurred beyond the site of impaction of the embolus. It may be possible to remove clot for a distance of several inches beyond the incision into the artery but if this is not rewarded by a gush of blood from the distal end of the artery perseverance is useless blood has clotted in the distal arterial tree and the limb is doomed. Small as it may be, the patient admitted late (more than 18 hours after the onset of symptoms) has a better chance of restoration of the circulation of the limb when treated by heparinization than when embolectomy is attempted. Unfortunately both the methods cannot be used simultaneously to close the incision and commence heparin therapy immediately will result in severe bleeding By the time the wound has sealed sufficiently for heparinization (say 12 hours) the situation will have become correspondingly more hopeless. So it comes about that a decision to attempt embolectomy is, in a sense a burning of one's boats.

AORTIC EMBOLISM

Saddle embolus of the aortic bifurcation is the exception to the rule that anticoagulant therapy is indicated in cases of under 6 and over 18 hours duration. The chief reason for this is that the heparinization, if it is going to benefit the patient, must lead to breaking up

of the clot into fragments which will lodge distally in less important branches of the affected artery. In the case of the aortic saddle embolus this would be disastrous: emboli would lodge in both external iliac, femoral, or popliteal arteries, necessitating bilateral operations. Moreover embolectomy on the aorta—an artery with a large diameter—is more likely to be successful than when the operation is performed on an artery of a smaller calibre. An embolus in this situation is amenable to surgical removal for a much longer period than more peripherally situated emboli. L. N. Atlas recorded successes up to 60 hours.

In spite of these favourable facets, the prognosis is poor. Most patients in whom an embolus becomes arrested at the aortic bifurcation are suffering from either congestive cardiac failure due to auricular fibrillation or recent coronary thrombosis, and it is on this account that if unreported failures are taken into consideration, the success rate probably is not more than 10-20 per cent.

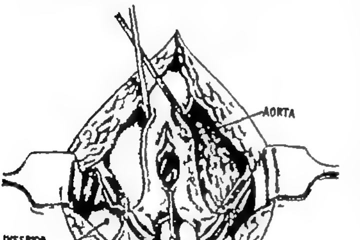

Fig. 1809.—Aortic embolectomy in progress. The aortic wall is being incised after the application of arterial clamps.

Diagnosis.—The condition should be suspected strongly if a patient with one of the abovementioned antecedents complains of sudden acute lower abdominal or back pain with paralysis of the legs. The diagnosis is certain if the legs are cold and anæsthetic below the knees and both femoral pulses are absent. Cyanosis is often present instead of pallor, but even in these cases, the legs are frequently painless.

Aortic Embolectomy.—General or spinal anæsthesia is essential. The latter is preferable as the better relaxation allows the intestines to be packed out of the field of operation more easily. A left paramedian incision allows the best access to the lower aorta and its branches (J. L. Madden) and the transperitoneal approach is quicker. After tilting the patient into the Trendelenburg position, the intestines are packed out of the way and the posterior peritoneum overlying the aorta and the common iliac arteries is incised. The surrounding areolar tissue is separated by blunt dissection, and at this point it is essential to occlude the common iliac arteries distally by whatever means are available (see p. 931) to prevent distal migration of the embolus, which might necessitate a further incision.

Lastly, the aorta is occluded proximally before incising it vertically for a distance of about 1 in. (2.5 cm.) above its bifurcation (*Fig.* 1809). After this the steps of the operation are the same as detailed under TECHNIQUE OF EMBOLECTOMY (see p. 941).

In the early post-operative period, anticoagulant therapy is unwise because of the risk of hæmorrhage, but a few days after operation long-continued oral anticoagulant treatment should be commenced to prevent further embolic episodes (J. W. Lord). This applies to all successful embolectomies.

ACUTE ARTERIAL THROMBOSIS

Sudden arterial insufficiency occurring in the absence of the usual causes of peripheral embolism (auricular fibrillation; recent coronary thrombosis) should lead to the suspicion of local arterial thrombosis at a point beyond the most distal palpable pulsation. The signs of ischæmia vary from mild to very severe, with a cold, pale, anæsthetic limb and intense pain. Easily palpable arteriosclerotic arteries elsewhere support the diagnosis.

An exact diagnosis is of academic interest only as the treatment is by heparinization (see p. 927). Removal of the clot by operation has no place in this condition because if attempted, it will be followed by further and more extensive intravascular clotting

RUPTURED AORTIC ANEURYSM

Surgical treatment of this condition formerly invariably fatal now offers hope. A number of cases have been reported where the ruptured aneurysm has been excised and the continuity of the aorta restored by a plastic prosthesis.

	No of Cases	Survivals
Javid et al.	4	2
Gerbode	1	1
Cooley and deBakey	18	11
Shumacker and King	5	2
Total	28	16

A surgeon who has the facilities and the ability should therefore attempt to save these otherwise doomed patients.

The essential points in the technique are —

1 Early operation with a midline incision extending from the xiphisternum to the pubis.

2. Large blood transfusions.

3. As soon as the aorta has been clamped above the aneurysm, and the common iliac arteries below heparin should be injected into the arteries below the distal clamps. Even so, as the circulation of the lower limbs will be considerably curtailed for several hours, widespread intra-arterial clotting is very prone to occur

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Revised by ALLAN CLAIN, M.B. (Cape), F.R.C.S. (Eng.),
Senior Surgical Registrar Royal Marsden Hospital, London

CHAPTER LXXXII

THE EXPOSURE OF THE BLOOD-VESSELS OF THE EXTREMITIES

THE SUBCLAVIAN AND AXILLARY ARTERIAL TRUNK

Exposure:—

Position of the Patient.—The patient lies with his shoulder projecting over the edge of the table. A small, narrow sandbag is placed under the upper thoracic spines. An assistant supports the arm held at right angles to the body.

Fig. 1810.—Incision for exposing the subclavian and axillary arterial trunk.

Incision.—The incision is made through skin only and consists of two distinct cuts. The first is parallel to and ½ in. (1.3 cm.) above the upper border of the clavicle. Secondly, the axillary extension of the incision is made to begin 1 in. (2.5 cm.) outside the inner end of the supraclavicular incision, and pass downwards towards the insertion of the pectoralis major (*Fig.* 1810).

Division of Muscles.—The pectoralis major is divided completely from the clavicle downwards. By slightly abducting the arm this muscle is put on the stretch and is severed with a few touches of the scalpel. The pectoralis minor is hooked up on the finger as in complete amputation of the breast; this muscle, too, is divided completely. The fascia is incised from the clavicle downwards, and branches of the acromiothoracic

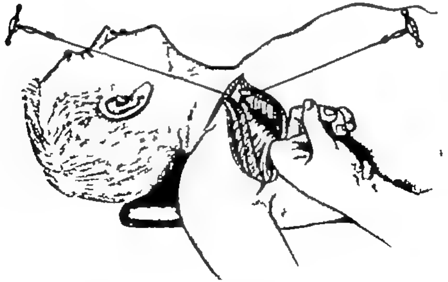

Fig. 1811.—Exposure of the subclavian and axillary arterial trunk. Dividing the pectoralis minor and the [illegible]. (*After Fiolle and Delmas.*)

artery are secured as necessary. It is highly important to ensure that the pectoralis major has been severed completely right up to the clavicle.

Section of the Clavicle.—The clavicle is divided as near as possible to its inner extremity the point of division should be abutting the clavicular head of the sternomastoid (*Fig* 1311) Clear this point with a periosteal elevator Slip a retractor under this portion of the clavicle and bore two holes through the bone from below upwards about ⅞ in. (2 cm.) apart Then divide the clavicle between the two holes with a Gigli s saw or chisel. If the chisel is used keep the retractor protecting the subclavian vessels.

Fig 1312.—Exposure of the subclavian vessels and the brachial plexus. (*After Fiolle and Delmas*)

At this stage, if the entire pectoralis major has been divided, the axillary space opens like a book under the mere weight of the arm (*Fig* 1312) A few fibres of the subclavius alone need division to give the most perfect exposure of an otherwise inaccessible region.

Reconstruction.—While the assistant raises the shoulder the clavicle is united with steel wire. The pectoralis minor is approximated with a running suture. The pectoralis major is drawn together by three or four deep mattress sutures tied moderately tightly If drainage is necessary a stab is made in the axilla for the tube.

THE THIRD PART OF THE AXILLARY AND THE BRACHIAL ARTERY

Exposure.—

Position of the Patient.—The arm should be supported at right angles to the body by an assistant. To rest the patient s forearm upon a small table (*Fig* 1313) is convenient

Fig. 1313.—Position of patient for exposure of the brachial artery Note that the upper arm is unsupported.

and prevents fatigue of the assistant. The arm between the axilla and elbow must not be supported. The surgeon may be seated facing the inner side of the arm.

Incision.—An ample incision is made in the line of the artery between biceps and triceps, but hugging the inner border of the biceps.

The fascia having been divided, the overlapping innermost fibres of the biceps are drawn upwards with a retractor. The median nerve is isolated and kept out of the way

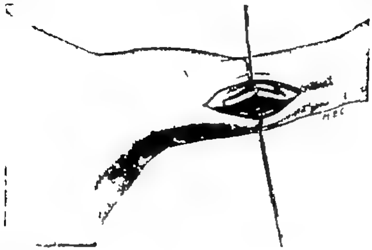

Fig. 1314.—Exposure of the brachial artery. The median nerve has been hooked upwards.

(*Fig.* 1314). The brachial artery with its two venæ comites is exposed. The artery may be much smaller than expected. It is sometimes duplicated, as I found in one case. Other anomalies may be present. The artery should be isolated from the venæ comites if it has been decided that ligation is necessary.

THE BRACHIAL ARTERY IN THE CUBITAL FOSSA

The arm is held or supported on a table. The operator stands or sits on the medial side of the arm. An incision is made along the inner border of the tendon of the biceps. The median basilic vein is pushed aside and the bicipital aponeurosis divided. *Now partially flex the elbow.* On the brachialis is the brachial artery with the median nerve lying to its inner side. If the bleeding point is inaccessible, the incision can be prolonged in a downward direction, in the manner about to be described.

The Termination of the Brachial Artery; the Radial, Ulnar and Interosseous Arteries in the Upper Third of the Forearm.—In wounds of the upper third of the forearm it is impossible to determine whether the termination of the brachial, the radial, the ulnar or the common interosseous artery is the source of severe arterial hæmorrhage. It is obviously desirable to expose all the vessels, which can be done as follows.

Position of the Patient and Incision.—The arm is placed on a table in the manner described already, or it is held away from the trunk by an assistant. The operator stands on the outer side of the limb. The incision begins 1 in. (2.5 cm.) above the fold of the elbow medial to the biceps. Proceeding distally, it is carried to the fold of the elbow and from thence in a ㄣ manner towards the middle third of the radius, where it ends (*Fig.* 1315).

The incision is deepened and the median basilic vein ligated. The bicipital aponeurosis is divided, and the median nerve comes into view. The pronator teres is retracted, and on the outer side of the median nerve the brachial artery will be seen. Place a second retractor under the brachioradialis. With the finger break through the extremely loose cellular tissues between these two muscles. The bifurcation of the brachial artery is clearly demonstrable. The radial artery under cover of the brachioradialis is readily exposed. The ulnar artery, the larger vessel, lies more deeply. *Pronate the forearm strongly.* Under these conditions strong retraction of the pronator teres opens up the area marvellously (*Fig.* 1316). With a little dissection the ulnar artery can be followed as it lies on the flexor digitorum profundus for 5 or 6 in. (12.5–15 cm.). Near the bifurcation one can see the commencement of the common interosseous artery for a short distance.

Reconstruction.—As nothing of importance has been divided it is only necessary to unite the fascia and the skin.

Fig. 1315.—Position of patient and incision for exposing the termination of the brachial artery the radial, the ulnar and the common interosseous arteries in the upper third of the forearm.

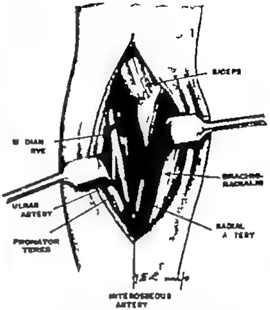

Fig 1316.—Exposure of the termination of the brachial artery The radial, the ulnar and the common interosseous arteries are displayed by suitably retracting the pronator teres and the brachioradialis. (*After Fiolle and Delmas.*)

THE RADIAL AND ULNAR ARTERIES IN THE LOWER TWO-THIRDS OF THE FOREARM
(*Fig* 1317)

The arm should be supinated fully and supported on a table.

Ulnar Artery.—The pisiform bone is palpated, and the incision is commenced along the radial side of the flexor carpi ulnaris. After the wrist has been flexed, the flexor carpi ulnaris is drawn to the ulnar side the other muscles being retracted to the radial side. Splendid exposure of the ulnar artery and nerve is thereby obtained.

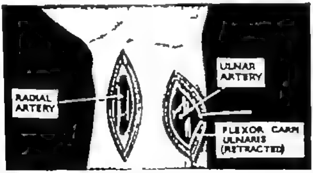

Fig. 1317.—Exposure of the radial and ulnar arteries t the wrist.

Radial Artery.—This part of the radial artery is readily exposed in the line of the pulse—that is, between the brachioradialis and the flexor carpi radialis.

THE ARTERIES OF THE PALM

A bleeding artery in the palm should be sought after a pneumatic tourniquet has been placed on the upper arm ; the tourniquet can be released as necessary to help to identify the bleeding point In the rare event of hæmorrhage from the palm being uncontrollable

it is the brachial artery that should be exposed and ligated. Ligation of the radial and ulnar arteries at the wrist may prove insufficient as the following case exemplifies.

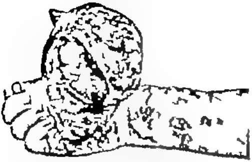

Fig 1318.—A case of fungating sarcoma of the first metacarpal bone in which ligature of the radial and ulnar arteries at the wrist failed to stop hemorrhage

The patient had a sarcoma of the first metacarpal. A piece was removed for section, and severe hemorrhage occurred. The radial and the ulnar arteries were tied, and the patient was transferred to another hospital some miles distant. On arrival the dressings were soaked in blood, and the patient by this time was severely oligæmic. After blood transfusion the arm was amputated. *Fig* 1318 shows the condition of the hand. The incisions for ligation of the radial and ulnar arteries can be seen.

THE EXTERNAL ILIAC ARTERY

An incision is made ½ in. (1.3 cm.) above the inguinal ligament. It is a long incision, and is comparable to that for femoral herniotomy by Lotheissen's method but in this case the incision curves upwards somewhat towards the anterior superior iliac spine (*Fig* 1319). The aponeurosis of the external oblique is exposed and divided in the length of the incision. The conjoint tendon is defined. Those fibres of the internal oblique attached to the inguinal ligament are made taut by retraction and divided close to the inguinal ligament. This exposes the fascia transversalis. The inferior epigastric vessels may be avoided but it is usually best to divide them between ligatures. The division of these vessels opens up the plane between the fascia transversalis and the peritoneum. After working in this plane with the finger the fascia transversalis is divided. The remainder of the exposure is performed entirely with the fingers. The peritoneum is lifted up and gently eased until the external iliac vessels are in full view (*Fig* 1320).

Fig 1319.—The incision for ligating the external iliac artery

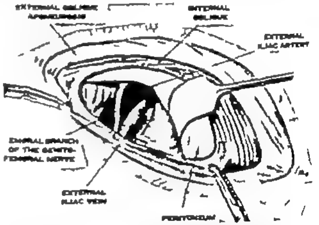

Fig 1320.—Exposure of the external iliac artery. The peritoneum has now to be peeled off the external iliac vessels with the finger

Ligation of the external iliac artery is required only exceptionally. It is not a reliable method of stopping bleeding from a wound of the thigh, for often anastomotic circulation allows renewed hæmorrhage; wounds of the common femoral should be attacked directly. Ligation of the external iliac artery should be reserved for secondary hæmorrhage from an infected wound high up in the femoral triangle or for malignant ulceration involving the main vessel in this situation.

A. W., aged 31 had an indurated ulcerating mass in the groin (*see Fig* 1319). No primary focus could be discovered. Two days after admission a violent arterial hæmorrhage occurred.

A tight bandage over a dressing partially controlled the hæmorrhage. The external iliac artery was ligated and the hæmorrhage ceased. The patient was treated with deep X-ray therapy without much benefit.

THE FEMORAL ARTERY

The Upper Two-thirds.—Exposure of the upper two-thirds of the femoral artery presents no difficulty. The surface marking is from a point midway between the symphysis pubis and the anterior superior iliac spine to the adductor tubercle, the limb being slightly flexed at the knee and rotated externally. An incision is made on this line. After incising the fascia the sartorius is identified, mobilized with the finger and then retracted. With a little dissection the femoral artery and vein are identified easily and can be traced upwards or downwards as circumstances demand (*Fig.* 1321). Ligation of the *common* femoral artery should be avoided whenever possible. If practicable this artery should always be repaired.

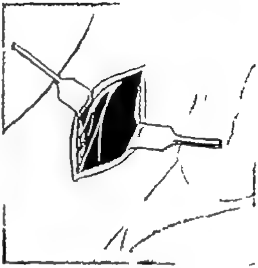

Fig. 1321.—Exposure of the upper third of the femoral vessels.

I was called to see a girl of 15 who had had an operation for osteomyelitis of the lower third of the femur fourteen days earlier. Twelve hours previously considerable hæmorrhage had occurred from the wound, but this had been controlled by packing. An hour previously violent hæmorrhage had occurred, and a tourniquet was in place around the thigh. She was very blanched, and the pulse was 140 and poor. The tourniquet was loosened, and as no arterial hæmorrhage occurred we decided to perform blood transfusion first. As soon as compatible blood had been procured, the tourniquet was reapplied and the transfusion carried out. The patient was then anæsthetized and the femoral artery exposed

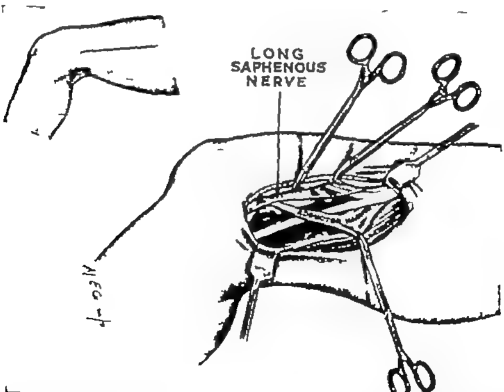

Fig. 1322.—Exposure of the femoral artery as it passes through the opening in the adductor magnus. A large part of the popliteal artery is also available. The tendinous expansion of the adductor magnus has been drawn towards the operator while the aponeurotic roof of the adductor (Hunter's) canal has been drawn away to expose the femoral vessels. (*After Fiolle and Delmas.*)

in the middle third of the thigh. The profunda femoris was ligated above the first perforating artery. Probably as the result of the blood transfusion, the convalescence of the patient, which had been slow, was much enhanced.

The Lower Third of the Femoral Artery and the Upper Half of the Popliteal Artery.—The following method is designed to expose the femoral artery where it passes through the opening in the adductor magnus. Incidentally it gives good exposure of the upper half of the popliteal artery.

Position of the Patient.—This is most important. The buttocks are placed as near as possible to the edge of the table. The assistant grasps the lower leg and foot, flexes the knee and abducts and at the same time externally rotates the thigh. The surgeon stands on the inner side of the manually supported limb facing the region to be explored. The only necessary landmark is the tendon of the adductor magnus.

Incision.—Palpate the upper edge of the medial femoral condyle, feel the tendinous insertion of the adductor magnus, trace the tendon upwards along this line. Commencing at the insertion, make an incision 6 in. (15 cm.) long.

In the upper part of the incision the sartorius will be seen. Mobilize this muscle with the finger. Run the finger upwards and downwards on the under surface of the tendon of the adductor magnus, cleaning it within the limits of the incision. When the muscle

Fig. 1323.—Incision for exposing the popliteal artery and the commencement of its terminal branches—namely, the anterior tibial, the posterior tibial, and the peroneal arteries.

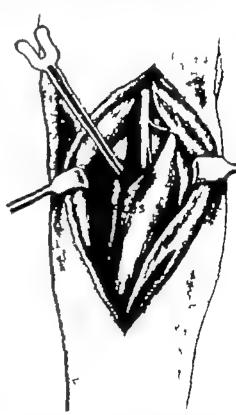

Fig. 1324.—Exposure of the lower part of the popliteal artery and the origins of its posterior tibial, anterior tibial, and peroneal terminals. The soleus muscle is about to be split on a director. (*After Fiolle and Delmas.*)

is clearly defined, with the scalpel open the aponeurotic roof of the adductor (Hunter's) canal close to the upper and external border of the adductor magnus tendon. Place two hæmostats on the edge of the tendon and draw it towards you. Then place two more hæmostats on the divided aponeurotic roof of the adductor canal and give them to an assistant to retract away from you. With blunt dissection the femoral vessels can be traced from the adductor canal through the opening in the adductor magnus, right on into the depths of the popliteal space (*Fig.* 1322). It will be noted that the only guide is the

tendon of the adductor magnus. If this fact is remembered then there is no difficulty in exposing clearly the whole course of the artery in this inaccessible situation. Should it be necessary the tendon can be divided and repaired after the operation on the artery has been completed.

THE LOWER THIRD OF THE POPLITEAL ARTERY TOGETHER WITH THE ORIGINS OF THE ANTERIOR TIBIAL, THE POSTERIOR TIBIAL, AND THE PERONEAL ARTERIES

Position of the Patient.—The patient lies on his abdomen, and the assistant holds the foot so as to be able to flex the knee at the proper time and thus relax the gastrocnemius and the soleus.

Incision.—This is shown in *Fig* 1823

The short saphenous vein and the sural nerve are isolated and retracted to one side The interval between the heads of the gastrocnemius is identified and these muscular bellies are separated. In the upper part of the wound the bellies come apart readily with the handle of the scalpel In the lower part the knife must be used By retraction the bellies are separated widely The popliteal vessels and nerve are dissected in the upper part of the wound. They are traced until they pass down the tunnel deep to the soleus. Under the soleus at this point a director is passed (*Fig* 1824) Keeping rather nearer the tibia than the fibula, the soleus is split on the director The popliteal artery can now be followed downwards to its division into anterior and posterior tibial branches the former vessel often passing *directly forwards* and so not visible from behind, at once comes into view when the main arterial trunk is inspected from the side. From the posterior tibial branch the origin of the peroneal artery can be displayed. If any of these divisions of the popliteal artery is found to be the source of the hæmorrhage it can be ligated. Thus the popliteal artery itself may be spared, which is a most desirable thing for ligature of this artery in its lower third is followed by gangrene of the foot in more than 25 per cent of cases.

THE BLOOD-VESSELS OF THE POSTERIOR ASPECT OF THE LEG (POSTERIOR TIBIAL AND PERONEAL)

Position of the Patient.—The patient lies on his abdomen with his foot over the end of the table. The operator stands at the foot of the table in order to view the leg longitudinally

Incision.—This commences two finger-breadths below the fold of the knee-joint. It is carried downwards between the heads of the gastrocnemius and ends on the inner side of the tendo Achillis, 1 in. (2 5 cm.) above its insertion (*Fig* 1825)

Fig 1825.—Incision for exposing the posterior tibial artery

The short saphenous vein and the sural nerve are identified and retracted outwards. The nerve is situated between the heads of the gastrocnemius and is a good guide to the interval between the two bellies. Commence at the lower end of the incision Divide the fascia on the inner side of the tendo Achillis. Push the finger upwards in the loose connective tissue on the deep surface of the tendon. This carries one right up to the anterior surface of the soleus. Here the finger remains as a guide. Separate the heads of the gastrocnemius, splitting the muscle with the scalpel (*Fig* 1826) Then divide the soleus strictly in the middle line the finger beneath allows this to be done boldly As long as these muscles are divided exactly in the middle line no harm will result from this extensive incision. When the gastrocnemius and soleus have been divided, the tendo Achillis can be split down its middle as far as the wound allows. Retractors are now inserted. Under a thin layer of fascia the posterior tibial nerve will be seen. On its inner side are the posterior tibial vessels; ½ in. (1 3 cm.) on the outer side the peroneal vessels will be seen (*Fig* 1827).

Reconstruction is performed easily with a few interrupted sutures in the muscles. The tunnel on the inner side of the tendo Achillis, made by the finger burrowing upwards, can be used for drainage if necessary

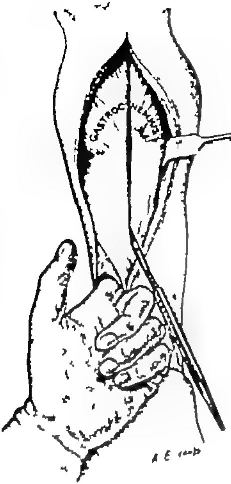

Fig 1826.—Exposure of the posterior tibial artery. Splitting the gastrocnemius.

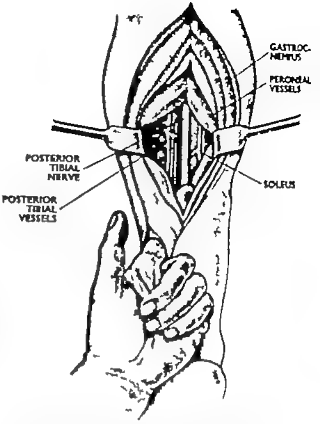

Fig 1827.—Exposure of the posterior tibial vessels and nerve, and the peroneal vessels. The gastrocnemius and the soleus have been split. (*After Fiolle and Delmas.*)

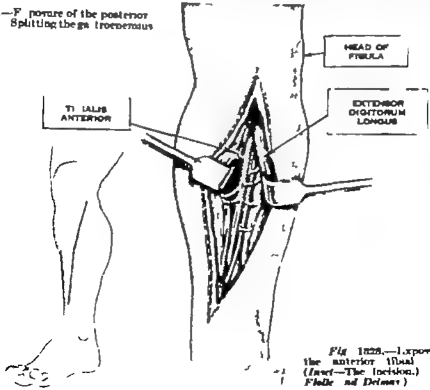

Fig 1828.—Exposure of the anterior tibial vessels. (*Inset*—The Incision.) (*After Fiolle and Delmas.*)

THE ANTERIOR TIBIAL ARTERY

Incision.—Palpate the head of the fibula, then the crest of the tibia at the same level. In the intervening space between these bony points lie two muscular masses—a large inner, the tibialis anterior, and a smaller outer, the extensor digitorum longus. The incision commences in the depression between these two muscles at the level of the head of the tibia. It proceeds downwards to the lower part of the middle third of the tibia, almost imperceptibly approaching the tibial crest as it does so.

Commencing towards the lower end of the wound, identify the two muscles. Dissect them apart, then, with the finger below, aided by a few touches of the scalpel, separate them completely in the whole length of the incision. Retract these muscles strongly, and the anterior tibial vessels and nerves are in full view (*Fig.* 1328).

SUBGLUTEAL HÆMATOMA

Exposure of the Superior Gluteal, Inferior Gluteal, and possibly Internal Pudendal Arteries.—In wounds of the buttock with a large subgluteal hæmatoma it is impossible

Fig. 1329.—Incision for exposing the vessels concerned in a subgluteal hæmatoma.

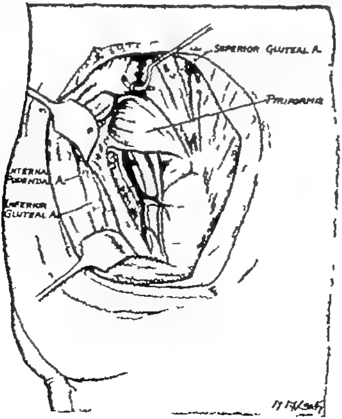

Fig. 1330.—Exposure of the superior and inferior gluteal arteries. The underlying structures seen on retraction of the gluteus maximus. (*After Fiolle and Delmas.*)

to tell which of these arteries is bleeding. Consequently a wide exposure which displays the anatomy of the region is necessary.

Position of Patient.—The patient is prone, and a flat pillow is placed under the pelvis on the affected side. An assistant slips one hand under the knee and with the other holds the foot. By externally rotating the thigh he is able to relax the gluteal muscles.

Incision.—*Fig.* 1329 shows the incision. It commences over the middle of the great trochanter, sweeps upwards, and then passes in a curved manner to the posterior superior iliac spine.

After fat has been cleared away, the fibres of the gluteus maximus will appear in the upper part of the wound, while in the region of the great trochanter very white tough fascia will be observed. Concentrate on this fascia. Incise it vertically over the great trochanter. In so doing a bursa is often opened. Pass the finger under the fascia, and it will enter a large potential space beneath the gluteus maximus. Aided by the finger beneath, detach the gluteus maximus with scissors, cutting as near as possible to the iliac crest where the muscle is mainly aponeurotic. Once the gluteus maximus is detached and drawn backwards with a large retractor, the underlying structures are accessible (*Fig.* 1330). Seek the piriformis muscle. With a little blunt dissection the superior gluteal artery can be seen passing to the deep surface of the gluteus maximus. If the superior edge of the gluteus medius is lifted up with a retractor, the deep division of the artery will be found; by tracing the deep division the main trunk, issuing from the sacro-sciatic notch, will soon become apparent. The main trunk can be ligatured here when necessary. Emerging from below the piriformis is the inferior gluteal artery. Deeply placed, winding around the spine of the ischium, is the internal pudendal artery with the pudendal nerve and nerve to the obturator internus. For a very short part of its course the internal pudendal artery is available from this aspect.

REFERENCE

FIOLLE, J., and DELMAS, J., *Surgical Exposure of the Deep-seated Blood-vessels*, 1921. London.

CHAPTER LXXVIII

GANGRENE OF THE EXTREMITIES

The higher the amputation, the higher the mortality (R. R. Lynn.)

In the comparatively early painful stage the ischaemic foot is nearly always pink, the skin being shiny and atrophic as though it was stretched tightly over underlying structures (W Oakley). At a later stage of dry gangrene the foot is white and its skin dry and scaly in these circumstances there is little or no pain, and gangrene, if present, is likely to advance more rapidly Ninety-nine per cent of cases of gangrene of the toes and the lower extremity are the result of arrest of the arterial flow only 1 per cent are due to venous obstruction.

Therefore of cardinal importance is feeling the pulses. To palpate the popliteal artery the patient must be prone. Some time should be spent in endeavouring to locate the dorsalis pedis artery or if this pulse is absent, the posterior tibial or the peroneal arteries should be sought. The latter if present, will be found ½ in. (1 3 cm.) anterior to the lateral malleolus. In many instances such examinations, together with testing the urine, will suffice to formulate a conclusion as how best to proceed in others further information regarding the arterial supply to the limb will be required.

Plain Radiography.—X ray examination of the lower limbs for evidence of calcification is too often misleading to be of any real value advanced calcification being compatible with good pulsation and patency of the artery affected. Radiography of the bones and joints in the vicinity of the gangrene is, however almost essential. Unsuspected necrosis of bone and effusion (purulent) into associated joints are revealed thereby and when present call for an earlier and perhaps a more extensive, operation than would be required otherwise. It is necessary to remind the reader that osteomyelitis is not apparent radiographically in its early stages.

Oscillometry.—The Pachon oscillometer is an instrument like a sphygmomanometer The needle of the instrument registers the amplitude of the pulse wave on a dial. The oscillometer is applied at various levels from above down the limb and readings are taken at the mid thigh, calf and ankle of *both* lower limbs. A sudden decrease in excursions of the needle is observed when the level of a recent occlusion of a main artery is reached, but as a rule it is the comparisons of readings at the same level on each side that are so important. Except in special clinics, an oscillometer is not often available. The main practical application of this instrument is that when adequate oscillations at the ankle are registered, a conservative operation below this level is likely to prove successful.

Arteriography undoubtedly provides more accurate information than other methods of investigation, and it may reveal the site of the obstruction if this is localized. However it is often unnecessary especially in cases with generalized occlusive vascular disease. This examination should be undertaken only if the patient is reasonably fit and when more information about the arterial supply to the limb is of fundamental importance. Before it is undertaken good renal activity must be assured, and in all cases iodine idiosyncrasy should be tested by a controlled patch test on the skin and, if this is negative, 1 ml. of diodone is injected intravenously about four hours later Only if there is no reaction to both these tests is the arterial injection undertaken. The greatest dangers of arteriography in these cases are detachment of a mural plaque and that a high concentration of diodone may precipitate further thrombosis. The second risk can be guarded against by injecting 40–60 ml. of weak heparin-saline solution at the conclusion of the diodone injection (D M. Morrissey)

GANGRENE THREATENED

One injection of 50 mg of priscol[1] intra-arterially sometimes brings about a dramatic change for the better within half an hour blue discoloration gives place to a healthy pink, and pain departs. Naturally it is problematical how long the good result will last, but sometimes it is for months or years.

[1] Ciba Laboratories Ltd., Horsham, Sussex.

GANGRENE INEVITABLE

Preliminary Management.—The problem of former days, as to whether to allow the gangrenous area (if dry) to separate spontaneously or to operate does not appertain at the present time. Owing to the frequent disasters attendant upon the former method, comparatively early operation—the nature of which will be detailed—is now advocated almost universally in cases of gangrene that are more than skin deep. How to effect separation of dead and non-viable tissue from the living with the least danger to the patient is the theme of this chapter. Even in patients classified as having dry gangrene some infection must be presumed, and it is necessary only to examine a well-defined line of demarcation to discover tiny beads of pus. Therefore early antibiotic therapy is required in all cases. When circumstances allow no time should be lost in sending a specimen of the discharge to the bacteriological department for the usual investigations. Unless the gangrene has reached a level where a considerable amount of muscle is involved, or is obviously spreading rapidly sufficient time should be allowed for antibiotics to control the infection before operation. In cases of diabetes the optimum time to operate should be chosen by the physician.

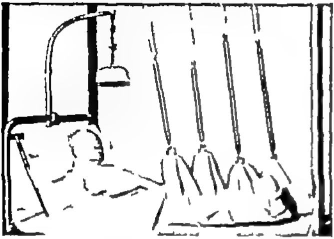

Fig. 1331.—Spring suspension of the lower limbs. (W. Oakley.)

During this waiting period the output of urine must be charted and measures taken to see that it is adequate. A daily blood urea examination is helpful. If facilities exist, frequent spectroscopic examinations of the urine for myohæmoglobin are desirable.

Protecting the Feet.—Whether the condition is due to ischæmia, neuropathy or both, there is always the danger that with the patient in the supine position pressure on the heels will cause blistering, ulceration or gangrene. The best method of preventing these complications is to swing each limb just clear of the mattress by means of two long springs (*Fig.* 1331), such as are used by physiotherapists, the tension of the springs being 30–50 lb. (13·6–22·8 kg.). The slings are made of canvas lined by orthopædic felt. A strap attached to the distal sling is passed around the sole, to prevent the development of equinus deformity (W. Oakley et al.).

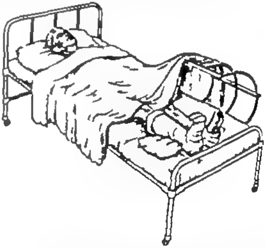

Fig. 1332.—Method of placing a bed-cradle so that the patient cannot injure the toes against it.

If for some reason—there are no contra-indications—slinging the legs cannot be undertaken, very special nursing care of the feet is required. After wiping them with spirit they are wrapped in soft cotton-wool; this is required whether slings are employed or not. A generous pad of wool is placed beneath each heel after it has been smeared with lanoline. The wool is kept in place by a sterile towel fastened with safety pins. Bandaging is avoided. So often is a bed-cradle the cause of patients injuring their toes on the iron bars that Sol Cohen's method of placing one edge of the cradle under the side (*Fig.* 1332) or foot of the mattress should always be employed. Thus the bedclothes are kept lifted. The feet are kept encased in wool for another reason—to conserve warmth. The practice of leaving the extremities exposed to the air or lightly covered is condemned; it causes vasoconstriction

of the cutaneous vessels and oxyhæmoglobin dissociates poorly at low temperatures The recent practice of nursing the patient with the heart higher than the feet is also condemned this causes retardation of venous return, and consequently resistance to the already enfeebled arterial inflow It also favours peripheral œdema and venous thrombosis. The bed and the lower limbs should be kept horizontal.

Analgesics and Hypnotics.—The pain of ischæmia is sometimes intense at others, especially in cases of diabetic gangrene, it is slight. In many patients alcohol is effective in relieving severe discomfort, assisting vasodilatation, and promoting sleep For intense pain morphine should be given, and repeated as necessary In less severe cases chlorpromazine is a suitable alternative When necessary sleep must be induced omnopon gr ⅓ (22 mg) and nembutal gr ii (0·2 g) often prove a useful combination.

Vasodilator Drugs.—Except, possibly the one dose referred to on p 937 in cases of *threatened* gangrene vasodilator drugs are best avoided altogether They can have little or no action on a limb which is the seat of advanced arteriosclerosis. When the arteries are capable of dilatation these drugs induce general vasodilatation that causes a fall of blood pressure which is likely to impair the collateral circulation, and may precipitate cardiac incompetence.

Anticoagulant Therapy (heparin) is of distinct value in many patients. If operation becomes necessary the heparin should not be stopped on this account. If during the operation hæmorrhage appears to be excessive an injection of 50 ml. of 1 per cent protamine sulphate[1] solution diluted with an equal volume of normal saline solution given very slowly intravenously restores the original coagulation time of the blood in a few minutes. Excessive bleeding at operation is not usual if anticoagulants other than heparin have been employed, but as there is available such an effective, quick-acting antidote to heparin, it is best to confine pre-operative anticoagulant therapy to this one drug in these cases.

Lumbar Sympathetic Nerve-block sometimes proves helpful in cases where the supplying arteries are not bereft of all elasticity

* * * * *

Before leaving the subject of the pre-operative management of gangrene of a part of an extremity it is necessary to urge once again that attention be paid to the sound side, lest it, too, become involved likewise to care for it tenderly while the patient is on the operating table and subsequently As to the side of the lesion, in every case of gangrene it is still necessary to stress the evil of each and all of *the deadly triad of Boyd*, to wit (1) Elevation of the limb (2) The application of heat to the limb (3) Keeping dry gangrene dry Above all, one should strive constantly to eradicate the deep-rooted idea that the cold feet of a patient with impaired circulation require added heat in the form of hot water bottles, etc.

Gauze soaked in equal parts of glycerin and spirit is a dressing *par excellence* for a dry gangrenous area.

ARTERIOSCLEROTIC GANGRENE (SENILE GANGRENE)

The incidence of arteriosclerosis obliterans is increasing in all European countries it is tending to appear at an earlier age than formerly and because of the increased expectancy of life a larger proportion of the population reaches an age when sclerotic arterial changes occur Arteriosclerosis is the commonest cause of gangrene of 211 consecutive cases, 107 were due to arteriosclerosis (Lynn and Modlin) The contralateral foot may become involved simultaneously or consecutively

Diagnosis.—The gangrene frequently commences as a blister containing blood-stained fluid, or as chronic paronychia. Men are much more frequently affected than women, and 80 per cent of the patients admitted with major gangrene give a history of many years of progressive ischæmia. In some of the remainder there is a sudden onset suggesting that the lesion is due to thrombosis of the femoral or popliteal artery In severity the pain is midway between the agony interfering with sleep of gangrene due to thrombo-angiitis obliterans and the slight pain of diabetic gangrene. Usually the gangrene commences in

[1] Boots Pure Drug Co. Ltd., Nottingham.

the great toe and spreads gradually towards the heel (*Fig* 1333) and then with greater rapidity towards the calf Like diabetic gangrene, it often follows a slight injury The arteries are palpable as hard, pulseless cords, although there may be pulsation of the femoral artery The tendency is for the gangrene to become arrested temporarily at a larger joint. Usually the dorsal surface of the foot is more affected than the plantar surface

Arteriographic studies show that gangrene limited to a toe is commonly due to a major arterial block high in the limb, the superficial femoral artery being the most frequent site. In about 10 per cent of cases the block is in the iliac arteries. The block can also occur in the popliteal artery at the level of the knee-joint in which case it spreads down to the bifurcation. In the aged, multiple blocks are a common finding

Prognosis.—If the thrombosis is confined to the tibial arteries it is possible that the gangrene will not spread above the metatarsophalangeal joint. If, as is common, the thrombosis involves the popliteal artery eventually gangrene will extend above the knee In the spreading type with a poorly formed line of demarcation, unless early above-knee amputation is performed the patient will die of toxæmia from absorption of metabolites of dying muscle or infection. In view of the fact that many of these patients are in a parlous condition from other causes, notably cardiac impairment and chronic bronchitis, it cannot be wondered at that the outlook is not encouraging Of 105 consecutive cases of senile gangrene occurring in patients of over 65 years of age I F McGoey reported that 50 were moribund on admission, and no operation was performed; 31 died as a result of a major amputation 2 after a minor amputation. Of the remainder but few lived more than a matter of months, and only 1 patient walked well with an artificial limb, there are very few patients over 70 years of age who can use an artificial leg following an above-knee amputation. In patients below the age of 65 the prognosis is less gloomy

Fig 1333.—Arteriosclerotic gangrene with a well defined line of demarcation.

Treatment.—When the gangrene is limited to one toe there is fairly uniform agreement that this toe should be amputated and left unsutured. In a large percentage of cases healing occurs, and at any rate for some months the patient is spared a major amputation. In other circumstances the right course to take is less stereotyped Many surgeons prefer to amputate through the middle third of the thigh, because of the greater certainty of primary healing Others, deploring the not inconsiderable mortality inseparable from this operation in the aged, and the indisputable fact that these patients very seldom can use an above-knee prosthesis, are not deterred by the prospect of having to reamputate in a proportion of cases, and practise more conservative methods. When gangrene is limited to the toes, transmetatarsal amputation is now popular and in some series 60 per cent have healed. If gangrene is too advanced for a transmetatarsal operation and there is a palpable popliteal pulse a below knee amputation should be performed. In doubtful cases it is worth while performing preliminary section 4 in. (10 cm.) below the knee in order to determine the permeability of the tibial arteries. More often than not these vessels are found to be almost or completely occluded, when amputation through the thigh must follow immediately but in a proportion of cases the blood-supply below the knee proves adequate.

ARTERIAL RECONSTRUCTION IN CASES OF GANGRENE, WITH SPECIAL REFERENCE TO ARTERIOSCLEROTIC GANGRENE

In selected cases, where the block has been proved by arteriography to be localized, a reconstructive operation has been performed with a small but increasing measure of success. If the patient is fit enough for a major amputation, he is fit enough for an arterial

reconstruction operation (C. G. Rob). Before a reconstruction operation can be entertained the essential proviso is that the patient's arteriogram shows an adequate arterial system below the occlusion. The best results have been obtained in patients with aortic or iliac occlusions, but many successes have been recorded when the occlusion was in the femoral artery.

An artery can be reconstructed in several ways but in cases of gangrene more success has followed thrombo-endarterectomy than any other method. This is because wound infection is by no means uncommon when there is a gangrenous lesion of the foot. Such infection causes little trouble when no foreign matter has been introduced (thrombo-endarterectomy). If a homologous arterial graft has been employed such infection is liable to cause secondary hæmorrhage. When it is not possible to perform thrombo-endarterectomy a by-pass procedure using either a homologous arterial graft or an autogenous vein graft (*see below*), gives good results. In this condition plastic prostheses are unsatisfactory even if only one end has to pass below the inguinal ligament although these materials have been employed with success to reconstruct the aorta and iliac arteries in cases of gangrene of the lower extremity.

Thrombo-endarterectomy.—The obstructed segment is exposed fully and incised in its long axis to the extent of the thrombus. The thrombus is excised together with the intima and the medial coat taking advantage of the line of cleavage which is present within the external elastic lamina. The artery is then repaired.

By-pass Procedure (de Bakey).—Comparatively short incisions are placed to expose the artery above and below the occlusion. Reference to the arteriogram in the operating theatre is essential for the proper placing of these incisions, an example of which is shown in *Fig.* 1334 A. Following exposure of the artery clamps are placed on either side of that portion chosen for the anastomosis (*Fig.* 1334 B) and a longitudinal incision is made through the arterial wall of a length corresponding to the diameter of the homograft or vein-graft that is to be inserted. A small elliptical piece of the arterial wall is removed with fine scissors. An end-to-side anastomosis is then performed between the end of the graft, which has been slightly bevelled, and the artery using the technique described on p. 932. After the first anastomosis has been completed, a subcutaneous tunnel connecting the two incisions is started by burrowing with the index finger of each hand. A long varicose vein probe is used to complete the tunnel unless a long hæmostat will suffice which is often the case if the distance between the incisions is not great. The free end of the graft is attached to the instrument, and in this way the graft is drawn along the tunnel being careful not to twist the graft. A second anastomosis is performed in the same way as the first. The lumen of the graft is filled with normal saline solution or heparin solution and clamped 1 in. (2.5 cm.) beyond its free end: this is a most necessary precaution to obviate air embolism. The clamps are removed, and bleeding from the suture line is controlled by gauze pressure and, if necessary, the application of absorbable gauze. The wounds are closed.

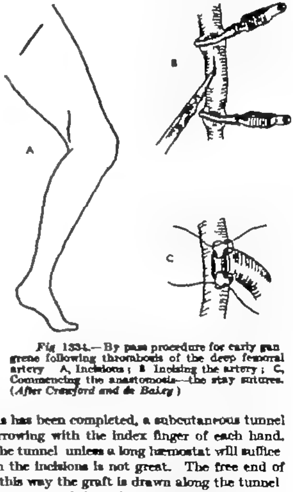

Fig. 1334.—By-pass procedure for early gangrene following thrombosis of the deep femoral artery. A, Incisions; B, Incising the artery; C, Commencing the anastomosis—the stay sutures. (*After Crawford and de Bakey.*)

Using this method the occlusion was by-passed successfully in 37 out of 40 cases operated upon by Crawford and de Bakey. In essence the operation adds a collateral vessel about the size of the main artery without interfering with those collateral vessels functioning at the time of the intervention.

Management of the Patient after a Reparative Operation.—After a reparative operation the patient should take dindevan[1] by mouth throughout the remainder of life, as regularly

[1] Evans Medical Supply Ltd., Liverpool 19

as a diabetic takes insulin (C. G. Rob). In this way the incidence of thrombosis in the reconstructed arterial segment and in other arteries is reduced. Should arterial reconstruction restore a palpable pulse distal to the occlusion, amputation of any kind should be postponed for at least six weeks. Only by then will there be a very definite line of demarcation, perhaps more distal than was thought possible. In some cases the gangrene will prove to be only skin deep and the gangrenous portion will peel off revealing healthy skin beneath.

THROMBO-ANGIITIS OBLITERANS (BUERGER'S DISEASE)

The patient is most often in the 20–40 age group and is frequently Polish Russian, Jewish or Japanese; however to a lesser extent all races are affected. The condition commences as an arteritis involving the intima and then the media. The inflammatory process causes soft red thrombi to occlude the lumen of the vessel. In about 30 per cent of cases there is fleeting phlebitis in the affected limb or limbs, which often heralds a fresh arterial thrombotic attack.

Diagnosis.—The disease is confined almost exclusively to males: in a series of 500 cases reported by L. Buerger there were only 3 women. In less than 2 per cent does the disease attack the upper extremities. The condition progresses by exacerbations and remissions, the exacerbations usually occurring during the cold weather. The disease commences with attacks of pallor and cyanosis (Raynaud's phenomenon) of the toes. Because the arterial thrombosis commences peripherally and extends proximally, ischaemia of the toes occurs early; therefore in this condition digital gangrene often appears before claudication. Fungus infection of the toes (athlete's foot) is common in this condition. Radiographs do not show calcification of the arteries.

Treatment.—When gangrene affects a toe, amputation of that toe can be carried out, but when this does not relieve the pain, and particularly if lumbar sympathectomy has been undertaken previously, or when the gangrene affects more than one toe or the foot, amputation through the leg 4 in. (10 cm.) below the knee is indicated. In thrombo-angiitis obliterans amputation through the leg is better than a transmetatarsal operation, and in a young or comparatively young person it is also preferable to one through the thigh, because an artificial limb is easier to control if the knee remains. Even after careful oscillometry it is sometimes extremely difficult to decide whether or not tissues below the knee have sufficient blood-supply to ensure good healing. Often the question can be answered only when the surgeon has made an incision and has examined the blood-supply of the skin and cut muscles. When an exploratory incision reveals that the tissues do not bleed freely, amputation through the lower third of the thigh must be carried out.

When gangrene is confined to the tips of the toes and the block is in the lower femoral or popliteal artery, a reconstructive operation of excising the affected arterial segment and substituting a vein graft (long saphenous) is sometimes most successful. The absence of pipe-stem arteries permits a satisfactory anastomosis to be made with no particular difficulty. It is important to reverse the excised saphenous vein, so that in its new situation the valves will be incompetent. The after treatment recommended by C. G. Rob, described on pp. 501, 502, is essential for success.

In the upper extremity tissue loss never extends proximal to the metacarpophalangeal joint.

DIABETIC GANGRENE

While arteriosclerosis is common in diabetes, and it often occurs at an earlier age than in non-diabetics, it has been assumed too readily that gangrene of the foot in diabetes is due to peripheral arterial disease alone or combined with a lowered resistance to staphylococcal infection. Careful examination shows that the great majority of diabetic patients have quite an adequate peripheral blood-supply, the common defect being diabetic neuropathy. *Peripheral nerve involvement, although occurring in diabetics of all ages,* is encountered more frequently in the elderly; the chief manifestations are sensory, the outstanding one being impairment of the appreciation of pain. Motor lesions also play a part—the cock up deformity of the toes frequently encountered in diabetics predisposes to a perforating ulcer over the plantar surface of one or more of the heads of the metatarsal bones. Appreciation of these facts, more particularly that the diabetic, even if the main artery supplying the limb is arteriosclerotic, usually has an excellent collateral

circulation, explains why conservative methods and local operations, which would be doomed to failure in an arteriosclerotic non-diabetic often prove successful in the treatment of diabetic gangrene.

Usually the gangrene (*Fig* 1838) follows minor trauma : improper cutting of toe-nails corns, and callosities is a very frequent cause Pressure of a tight shoe (the pain engendered is not appreciated) is also common. Interdigital fungus infection should be looked for

The early presenting lesion is nearly always one of the following —

1 Gangrene of a toe. In early cases this is almost always limited to the distal two-thirds, and dry in appearance

2. Perforating ulcer over the head of one of the metatarsal bones. The cock-up deformity of toes referred to above is often present in these cases.

3. A gangrenous patch on the heel, originating in a fissuring of the thick skin in the ambulatory and to pressure necrosis in those confined to bed.

4 Web space infection following fungus infection of the interdigital clefts.

Principles in General Treatment.—

1 The patient should be admitted forthwith and a physician requested to undertake the treatment of the diabetes. Effective and early control of the diabetes is obtained more easily in the elderly than in cases of primarily infected gangrene in a young diabetic.

2. Antibiotic therapy is given penicillin to commence with. If an opportunity to secure a specimen of pus presents culture and sensitivity tests are arranged.

3. *Both* legs are suspended as described on p. 958

4 Operative treatment is postponed until infection is controlled by antibiotic therapy and until the physician pronounces that the patient is fit for a general anæsthetic Only in cases of spreading gangrene, especially above the ankle, is there need to curtail preparatory measures to the absolute minimum, in which case the advisability of employing refrigeration anæsthesia should be considered.

Fig 1338.—Gangrene of toes occurring in a diabetic after contact with a moderately hot hot-water bottle. (*W L. Lowrie.*)

The Local Treatment of Various Lesions.—

An area of superficial necrosis can appear with remarkable suddenness, but provided further pressure is avoided and bed rest is insisted upon, usually these lesions heal uneventfully under purely conservative treatment. The foot is wrapped in a loose sterile dressing which is removed twice a day for a 15-minute foot bath, to which soft soap has been added. Foot-baths promote drainage and allow necrotic tissue which is separating to be removed with forceps and scissors viable tissues must not be touched during this procedure. The control of infection is a desirable, if not an essential, pre-requisite to any local operation, and while antidiabetic and antibiotic therapy is in progress, the above local treatment greatly enhances the success of a conservative operation.

Gangrene of a toe: As long as there is minimum infection there is little discomfort. Severe pain is suggestive of bone necrosis or purulent arthritis. It is usually wise to remove a single gangrenous toe by disarticulation and excision of the head of the metatarsal bone. Disarticulation *per se* has a tendency to impair the blood-supply to the adjacent toes moreover the exposed articular cartilage undergoes necrosis and healing is delayed (J Grunberg et al.). As a rule the wound is left open and allowed to granulate. Primary suture is undertaken only if hæmorrhage is free and if the skin edges can be approximated without tension. Amputation of the fifth toe with the head of its metatarsal bone leaves a raw area for which it is impossible to provide adequate skin cover Consequently when this toe is involved or more than one digit is gangrenous, transmetatarsal amputation should be undertaken. When healing by secondary intention is awaited, the skin edges are held loosely in apposition by petroleum-jelly gauze and covered by an ample dressing of fluffed gauze

Lesions of the sole: Once a perforating ulcer has occurred operation is essential. The object of the operation is to remove necrotic tissue and the underlying bone pressure point and to obtain skin cover without tension. When the toes are not involved, the gangrenous tissue is excised and the underlying pressure point, viz., the head of the metatarsal, is removed. Closure of the wound is permissible only when there is ample skin cover and an adequate blood-supply as judged by hæmorrhage at operation. As a rule the wound is not closed but is allowed to granulate healing being expedited by delayed pinch skin-grafts.

If it is necessary to remove more than one metatarsal head, usually a transmetatarsal amputation is advisable

Gangrene of the heel usually responds to local excision with or without subsequent skin-grafting. Radical excision of the heel tissues often involves removal of most of the fat pad of the heel. When bare bone lies at the bottom of the wound all presenting *cortical* bone of the calcaneus is chiselled away leaving a flat cancellous bony surface which, by virtue of its rich capillary bed, provides an adequate granulating surface for the application of delayed pinch skin-grafts. The patient should be confined to bed and the limb suspended until healing is well advanced. Provided weight is directed to the forefoot during ambulation, the scar remains healed.

Summarizing: In most early cases, as soon as the diabetes is under control the local lesion is excised or unroofed. The resulting wound is, as a rule, treated by delayed closure or when infected tissue cannot be excluded from the operative field, healing by granulation is awaited. In such cases sloughs can often be eliminated by moist dressings of streptokinase and streptodornase. When indicated pinch grafting is employed to cover the granulating areas. Sometimes the associated vascular impairment is such that clinical judgement dictates that the above extremely conservative operations are unlikely to succeed. At others the gangrene has passed the limits which make them possible. When the associated arterial deficiency is moderate, the fate of the limb after excision and drainage of gangrenous tissue will hang in the balance.

The presence of a palpable dorsalis pedis or posterior tibial pulse is a fairly certain sign of a favourable outcome but the amount of bleeding at the time of operation remains the most important demonstration that local excision will suffice

Mid leg amputation in diabetics: The number of failures of below knee amputation is sufficiently small to justify its almost routine use and re-amputation through the thigh can be performed on the few failures—4·7 per cent (S. Silbert). The advantages of below knee amputation are —

1. A lower mortality—above the knee 27 per cent, below the knee 9 per cent.
2. Better prospect of fitting and using a prosthesis.
3. Less pain in the stump.

The only contra indication is absence of a femoral pulse at the groin.

RARER FORMS OF GANGRENE

Threatened and Actual Gangrene from Injury.—The limb has been injured typically a wheel of a vehicle has passed over it and there may or may not be a fracture. There is an effusion in the region of the injury which is impeding the circulation. The foot is cold and mottled. If the circulation is not restored within an hour it should be assumed that the effusion is compressing a main artery and steps should be taken accordingly. A long incision through the deep fascia (*Fig* 1330) by releasing tension may allow the artery to function again. Referring to crushing injuries of the foot blood extravasated beneath the anterior annular ligament sometimes produces sufficient tension to jeopardize the blood supply to more distal parts. If reduction of a concomitant fracture does not release the tension, an incision with division of the anterior annular ligament is indicated (H. M. Childress). *In cases where no improvement follows these conservative operations, amputation becomes necessary*

An 11 year-old boy was brought to hospital, a wheel of a motor-car having passed over the middle third of his left leg. There was some bruising of the skin, which was intact. Radiographs showed that there was no fracture and he was allowed to go home. Four-and-a-half days later he returned. The foot was quite cold and the great toe was assuming a black tinge. The foot was lifeless. Amputation at the modern seat of election was performed. On dissecting the specimen

it was found that the posterior tibial artery had been torn across, and there was a hæmatoma in the neighbourhood of the anterior tibial artery. With these exceptions there was no gross damage.

Gangrene following Fractures of the Extremities.—Exceptionally the main artery is compressed or lacerated by a supracondylar fracture or separation of the epiphysis at the

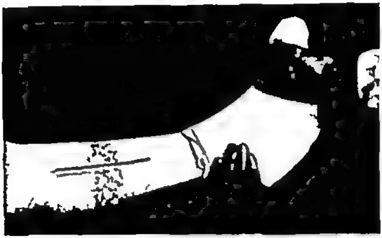

Fig. 1836.—*Incision in the case of a run-over accident with œdema threatening the circulation of the foot. Timely incision through the swollen tissues may avert amputation.*

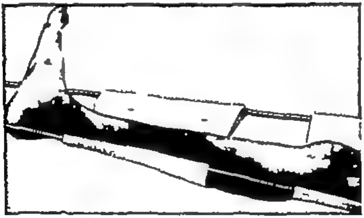

Fig. 1837.—Gangrene following strapping extension. (*D. S. Miller.*)

Fig. 1838.—Gangrene originating alongside the track of a Steinmann pin. (*D. S. Miller.*)

lower end of the humerus or femur. More commonly gangrene occurs in aged patients with fractures, particularly of the neck of the femur. Usually the cause of the gangrene is due to: (1) Traction applied at the time of the reduction of the fracture. (2) Strapping extension, in which case the gangrene commences in the stretched skin (*Fig.* 1837). (3) Pressure sores from a plaster cast. (4) Osteomyelitis via the track of a Steinmann or other pin (*Fig.* 1838).

As D. S. Miller and A. J. Harris, who reported 39 personal cases, state, this complication cannot be rare but is seldom reported. It might be thought that it could be avoided by treating the fracture by internal fixation, but gangrene occurs from time to time even after this form of treatment. In many of the cases high amputation becomes necessary and the mortality is very high 22 out of 39 patients died in Miller and Harris's series, while of 5 cases reported by McGoey all succumbed.

Frost bite.—Rubbing with snow is a procedure as dangerous as it is painful. On no account should the frost bitten limb be pinched or massaged, and to rub it with a coarse towel as has been recommended by some, is most inadvisable. Thawing should be as slow as possible.

First-aid Treatment.—If freezing has taken place for only a few minutes, the part should be covered with a warm hand or placed inside one's own clothing (R. Greene). Dabbing turpentine on the frozen parts has been found useful in minimizing the risk of gangrene. The trappers in Northern Canada used this remedy long before it was adopted as treatment in the hospitals of Canada (P. Berbrayer).

Course.—As a frozen hand or foot thaws, the pain, swelling and hyperaemia are intensified if the tissue is still viable. It is impossible to determine the extent of tissue damage without

Fig. 1839.—Gangrene developing after frost bite in a farm labourer.

prolonged observation. If there is complete loss of viability a line of demarcation (*Fig.* 1839) usually develops within a few days.

Treatment.—During the Korean War when frost bite casualties were found within four days after injury they were given an intravenous solution containing 250 ml. of 5 per cent dextrose 12 ml. of alcohol, and 250 mg. of procaine; provided there were no concomitant battle wounds that might have bled the solution given also contained heparin (*see* p. 927). This infusion was administered every 6 hours for 48 hours.

In otherwise young and healthy individuals, a conservative programme should be instituted. The affected part is wrapped lightly in sterile gauze and covered with a sterile towel, put to rest and antibiotic therapy instituted. It has been observed that the contraction of black necrotic eschar frequently results in ischaemic necrosis of a digit. To prevent this the eschar should be bivalved as soon as possible. If it is hard and thick, it can be softened by immersion in sterile lukewarm water containing liquid soap. The majority of black eschars exfoliate and leave healthy sensitive skin. Nails often exfoliate and are replaced by new nails.

In the case of a leg: After demarcation is complete, amputation is carried out through the chosen adjacent normal-appearing tissues, provided the clinical tests suggest an adequate blood-supply at this level. A breakdown of the primary suture line often occurred in cases treated in this way by Canty and Sharf. An average of five operations was required in order to achieve a satisfactory stump. If further sacrifice of a length of bone was undesirable a primary split skin-graft was often applied to cover the tissue defect. In 67 per cent of cases a major portion of the foot was preserved.

In the case of a hand the attitude should be especially conservative for often mummified fingers gradually exfoliate leaving normal digits. Consequently no-one can determine whether amputation will be required or not until after a period of three months has elapsed.

Immersion Hand or Foot is a separate entity and must be differentiated clearly from frost-bite. After rescue the immersed extremity passes through two, and sometimes three stages :—

Stage 1 lasts for a few hours to several days. As a result of anoxia, the permeability of capillaries is increased. The affected part is cold swollen often cyanotic, and pulsation in neighbouring arteries is weak.

Stage 2 continues for six to ten weeks. The part becomes dark red, and definitely more swollen. The pain is usually worse at night and in severe cases blebs, containing serous or hæmorrhagic fluid, appear Owing to the release of histamine-like substances there is general malaise, slight elevation of temperature and sometimes albuminuria Even if the entire hand or foot, and all the digits, are discoloured, it is unusual for even one digit to be lost, particularly in the hand. If gangrene develops it is usually superficial and with general systemic care will separate naturally

Treatment.—The patient should not be allowed to use affected hands, or to walk if the feet are involved After his wet clothing has been removed he should be wrapped in warm blankets, but on no account must artificial heat be applied. If œdema is much in evidence ice-bags around the area relieve pain and paræsthesia. Intravenous heparin is given in doses as necessary (see p. 027) every 4 hours for 48 hours, to prevent thrombosis in the peripheral vessels.

Fig. 1340.—Gangrene due to Raynaud's disease

Vesicles and blebs should not be opened Unless quite detached, the pulling-off of dead or sloughing tissue should be forbidden. On the other hand, the application of moist dressings of streptokinase-streptodornase to remove dead tissue is most desirable. When the œdema and swelling have disappeared passive exercises and warm whirlpool baths are helpful

Stage 3 does not always occur When it does, it often lasts for weeks or months, and consists of hyperæsthesia, smooth shiny hairless skin, telangiectases, and wasted and pointed digits with stiff joints.

Non-occlusive Symmetrical Gangrene.—In many of these cases the arterial pulses feel normal. In most instances the cardiac output is low The condition has also occurred in cholera and in carbon monoxide poisoning.

In most cases bilateral below knee amputation has become necessary

Occasional Causes of Gangrene of the Fingers.—Raynaud's disease is sometimes responsible (*Fig* 1340). The usual course recommended is to perform sympathectomy and when the line of demarcation is clearly defined to amputate in accordance with the principles set out on p. 971 In the case of gangrene due to cervical rib the index finger or part thereof, is amputated after clear definition of non viable tissue has occurred preferably following scalenotomy

Gangrene in Infants.—Spontaneous peripheral arterial occlusion during infancy is rare most cases occur within fifteen days of birth The aetiology is often a matter for speculation. However J Bret reported 3 cases of gangrene in a lower extremity of the newborn In each case the infant had received nikethamide (coramine) through the umbilical vein. The vasoconstrictor action of this drug is therefore a proven danger The better collateral circulation in an infant, as compared with an adult, provides some protection against extensive loss of tissue It would seem, therefore, that therapy should err on the side of conservatism, and that measures to increase collateral blood-flow be utilized Operation should be performed only after clear demarcation between viable and non viable parts. The initial treatment consists in supportive therapy antibiotics, and a rigid sterile technique in dressing A sympathetic procaine block was used in 3 cases reported by Stokes and Shumacker and gangrene that threatened a much larger area became limited to a toe or toes.

Phlegmasia Cerulea Dolens.—Although it is usually due to impairment of the arterial supply gangrene occasionally results from occlusive venous disease Phlegmasia cerulea

dolens is characterized by severe pain in a limb (nearly always a leg), very considerable swelling and rapidly developing cyanosis of the limb. The condition appears to be due to thrombophlebitis of the iliac and femoral veins associated with unexplained spasm of the femoral artery. Many of the reported cases occurred in female patients recently delivered; in a minority the possibility of puerperal origin of the thrombus did not appertain—indeed, in not a few instances the patient was a male. In non-pregnant cases the patient is often debilitated by another disease, e.g., ulcerative colitis (C. G. Rob), but cases have occurred following the injection of sclerosing agents for varicose veins. Many more cases of phlegmasia cerulea dolens occur than are reported, the main reason being that the patients are not observed carefully in the early stages, when the true nature of the pathology can be recognized, but only in the end stage of gangrene.

Measures that should be avoided. Because of the shock, and the fact that they do not act selectively, antispasmodic drugs should be avoided, for they would assuredly lower the blood-pressure. Paravertebral sympathetic block would seem to be contra-indicated because it increases congestion in an extremity the venous return of which is compromised.

Treatment.—As the condition is often associated with shock, the first consideration should be to administer dextran or plasma. Unless there is an obvious contra-indication,

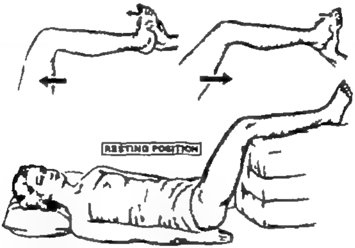

Fig. 1041.—Method of high elevation and leg exercises in early cases of phlegmasia cerulea dolens. (*After J. R. Veal.*)

such as very early delivery, anticoagulant therapy should be given. Contrary to threatened or established gangrene of arterial origin, where to elevate the limb is a misdemeanour, high elevation of the limb so as to aid the return of venous blood by subsidiary channels, and frequent exercises of the foot and leg as shown in *Fig.* 1041, is the treatment J. R. Veal and others have found very successful in early cases. In some cases gangrene ensues, when amputation through healthy tissue above the line of demarcation must be carried out without delay.

In the arm the condition has been attributed to intravenous infusion or injection, but some cases have occurred spontaneously. Gangrene, when it occurs, is practically confined to the digits.

As in all cases of phlebothrombosis, pulmonary embolism is a rather frequent complication of phlegmasia cerulea dolens.

REFRIGERATION ANÆSTHESIA

When the services of an experienced anæsthetist are not available, or in a very poor-risk subject, refrigeration anæsthesia, although somewhat troublesome, and in many instances resulting in a wet bed, is entirely satisfactory. Furthermore, it is the safest of all forms of anæsthesia. The maxim that a tourniquet must not be applied to an arteriosclerotic limb or in cases of diabetes is countered when the limb is to be refrigerated, for without a

tourniquet refrigeration anæsthesia is incomplete and the advantages of refrigeration anæsthesia often outweigh the dangers of the application of a tourniquet

Step 1.—Ice-bags are applied about the proposed site of amputation and left in place for about half an hour

Step 2.—A tourniquet is applied at least 3 in (7.5 cm.) above the proposed saw line With the parts chilled, this can be done without supreme discomfort During the application of the tourniquet pinching a fold of skin must be avoided studiously

Step 3.—When amputation of a toe or a transmetatarsal operation is to be perform[ed] and the patient is strong enough refrigeration is simple (*Fig* 1342). More usually a rub[ber]

Fig 1342.—Refrigeration for amputation of the toes when the patient is able to sit in a wheel chair (*After F M Allen.*)

sheet must envelop the extremity and within it cracked ice is packed around the whole limb including 3 in. (7.5 cm.) above the tourniquet (*Fig* 1343). If the head of the bed is elevated, the water can be made to drain into a pail. Two-and-a half hours of this freezing process, which is quite painless, are necessary A needle introduced into a main nerve will indicate if anæsthesia is complete.

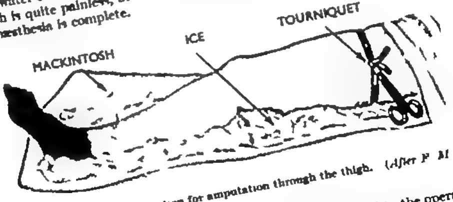

Fig. 1343.—Method of refrigeration for amputation through the thigh. (*After F M Allen.*)

Step 4.—The patient with the ice-bag still in position is moved to the operating [theatre.] The temperature of the theatre must be as low as can be obtained conveniently by [turning] off heat and opening windows. The whole theatre staff must be completely read[y for the] operation. There is no need for undue haste but there must be no waste of ti[me. The] tourniquet is unsterile and towels must be so arranged for its removal at the ap[propriate] time during the operation. Unless the temperature of the operating theatr[e is low,] anæsthesia can be expected to last for one hour At any rate there is plent[y of time] to perform a fairly expeditious amputation, and amputation by equilater[al flaps is] recommended.

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CHAPTER LXXXII

URGENT AMPUTATIONS

In works on operative surgery especially those designed to meet the needs of the examination room, much space is devoted to classical amputations Only a few stereotyped amputations are necessary in emergency surgery

Urgent amputations may be called for (1) In crushing accidents (2) In spreading gangrene of the limb; (3) In a grave infection of the limb threatening life, after antibiotics have had a just trial.

The first thought is to save the patient's life. The second should be to plan an amputation suitable for an artificial limb. These objectives must be before us in all amputations.

GENERAL CONSIDERATIONS

Prophylaxis against Gas Gangrene.—The skin in the neighbourhood of the anus is contaminated with intestinal bacteria to a greater distance than is generally supposed these bacteria include the *Aerobacter aerogenes* the spores of which are not destroyed by ordinary methods of skin disinfection (L. I Garrod). It should be recognized more widely that amputations either for obliterative arterial disease or through the upper part of the thigh—and particularly when both factors exist—involve an exceptional risk of gas gangrene. Such operations afford one of the few imperative indications for full penicillin cover and possibly if the prophylactic value of anti-gas-gangrene is allowed a prophylactic dose of this serum, also.

Anæsthesia.—In diabetic and arteriosclerotic patients anæsthesia is usually a problem. Spinal anæsthesia has been the choice of many surgeons nevertheless, as spinal anæsthesia tends to diminish the blood flow through the extremities, it is possible that it favours intra arterial thrombosis in the opposite extremity For this reason in the aged in those with peripheral arterial disease and in diabetic persons, nitrous oxide and oxygen or cyclo-propane with a relaxant is to be preferred. Referring to the diabetic patient, Chew Smith says there is no anæsthetic of choice—it must be chosen as best suiting the patient, combined with the capabilities of the available anæsthetist. Refrigeration anæsthesia is advocated by some, especially in infected cases but it has never become popular

Site of Amputation (*Fig* 1844) —In deciding the level of a lower limb amputation one must remember that if there is a choice of sites, particularly in an elderly person, the lower the level of amputation the greater the prospect of ambulation Nevertheless, before deciding to amputate below the knee in an arteriosclerotic patient the following factors should be taken into consideration: If simple amputation of a toe is carried out 50 per cent of the patients require re-amputation at a higher level within three months (Reeves and Quattlebaum). The frequency with which supracondylar amputation becomes necessary after below-the-knee amputation in arteriosclerotic patients varies so widely in different series that the incidence is problematical, but it is clear that it occurs sufficiently often to make it essential to weigh carefully all data relating to the probable viability of tissues at the proposed site of amputation. If after deliberation amputation through the leg below the knee is decided upon, should the cut muscles appear dusky and ooze but little, one must be prepared to abandon amputation at this level in favour of an above-the-knee amputation. Amputation must be performed through indubitably viable muscle as evidenced by a beefy red colour and a goodly capillary ooze

In the upper limb, it is of the highest importance to preserve the elbow joint if that be possible a prosthesis can be fitted to a stump if only 1½ in. (3·8 cm.) beyond the insertion of the biceps muscle can be retained.

Control of Hæmorrhage.—At the present time the tendency is to avoid using a tourniquet, unless it is obvious that the patient's arteries are in a youthful elastic condition. Sometimes in infected cases, by reason of œdema of the upper part of the limb, both the use of a tourniquet and external digital compression are rendered ineffectual In these

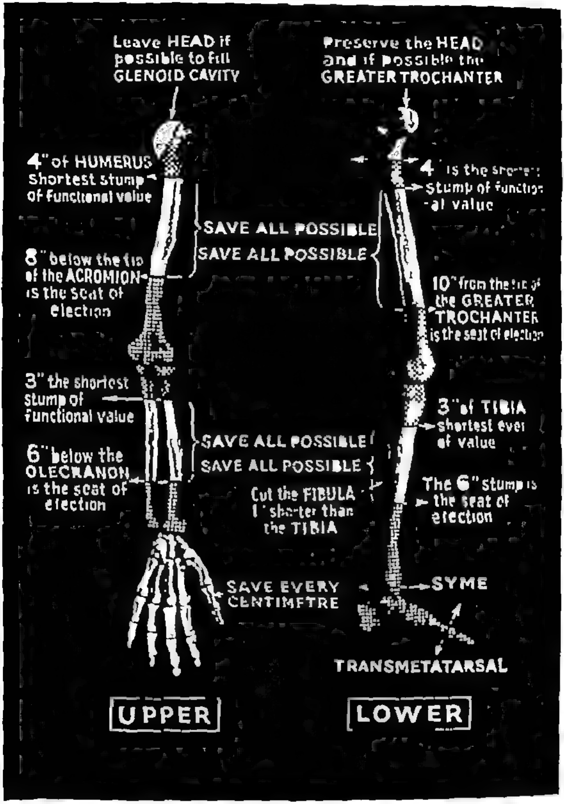


Fig. 1344.—Preferable sites for amputation from the point of view of fitting an artificial limb.

circumstances the correct procedure is, first, to expose the main vessels at the usual site of compression; then, as the surgeon commences to amputate, a gloved and gowned assistant compresses the vessels between the finger and thumb for as long as is necessary.

External Digital Compression in the line of the main artery is most often called for in the lower limb. Progressive gangrene of the foot due to obliterative arterial disease is a common indication for amputation and it is precisely in these circumstances that the evil effects of a tourniquet reach their zenith. Not only is the main artery liable to direct an undue injury but damage to the smaller arteries often results in thrombosis and occlusion of the very vessels upon which the nutrition of the stump depends. Hence for the control of hæmorrhage in arteriosclerotic subjects, digital compression, because it minimizes these risks, is the only method that should be employed. If he is not fully acquainted with the technique the assistant should be instructed where and how to compress the femoral artery before the operation is commenced.

The Application of a Tourniquet.—When it is considered that the application of a tourniquet will do no harm the limb should be elevated *for two minutes* in order to allow the blood to gravitate. A tourniquet is then applied with no greater pressure than is required to control the bleeding. It is important not to keep the limb elevated too long, for under these conditions vasoconstriction occurs, and when the limb is lowered and the vasoconstriction passes off the tourniquet may prove ineffective.

For the upper limb a sphygmomanometer cuff is the ideal tourniquet. For the lower limb the type of tourniquet is a matter for individual preference. A length of new ½ in. (1·3-cm.) rubber tubing retained by a strong hæmostat is second to none. Whenever a tourniquet has been employed, be vigilant in seeing that it is removed as soon as it has served its purpose.

Fashioning Flaps.—With very few exceptions flaps should be cut from without inwards. The scalpel, which should not be small, is held in a manner that gives perfect control of the blade (*Fig.* 1345). All the flaps should be fashioned somewhat longer than is necessary; they can never be lengthened but it is a simple matter to trim them appropriately at the end of the operation. While making this final adjustment, it should be borne in mind that the shorter the flap the better its nutrition.

Severing the Soft Parts.—Except for leaving a little muscle at the base of the flaps in most instances all the soft parts are cut at the level of the proposed section of the bone and a "tour de maître" is the technique recommended (*Figs.* 1346, 1347). For this purpose a Syme's knife (*Fig.* 1348) is desirable.

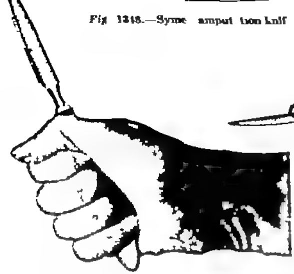
Retracting the Musculature.—An efficient muscle retractor, so essential for amputations, can be made from a piece of stout calico. For use in the case of the femur and humerus one slit is made (*Fig.* 1349 A). For amputations of the forearm and the leg below the knee a double slit is necessary (*Fig.* 1349 B) so that the tongue of material can be passed between the radius and ulna or the tibia and fibula. It is advisable to have the edges of the slit hemmed. The cloth retractor is sterilized by boiling with the rest of the instruments. To an assistant is delegated the sole duty of seeing that every portion of muscle is completely covered by the cloth, which is well and evenly retracted with both hands (see *Fig.* 1357).

Dealing with the Periosteum.—The ends of the bone should be denuded of periosteum for about ½ in. (1·3 cm.) above the line of section. Using a periosteal elevator [illegible] can be done before or after section of the bone. Removal of the periosteum [illegible] ing thickening of the end of the bone and spur formation.

Section of the Bone.—The saw-cut is commenced by steadying the [illegible] the thumb. By drawing the saw[1] towards one with a few light strokes a groove [illegible] cut in the bone. Vigorous sawing is then commenced. This process is greatly enhanced by having a stream of saline solution injected from a syringe on to the line [illegible] otherwise bone dust tends to collect and clog the cutting edge of the saw. The assistant must be told to hold the limb steadily, exerting slight, perfectly horizontal traction. He must understand that elevation will result in locking of the saw blade and depression will probably cause the bone to splinter. If time permits, the bone end [illegible]. It is most [illegible] with a file. Any spikes can be cut away with bone forceps. [illegible] protuberant edges such as the crest of the tibia.

[1] Alternatively a Gigli saw can be used with certain advantages (see [illegible]).

Fig. 1345.—Syme's amputation knife. The blade is 3½ in. (9 cm.) long.



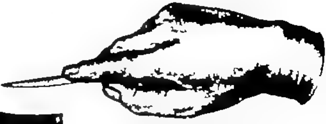


Fig. 1348.—Method of holding the scalpel while cutting amputation flaps.

Fig. 1346.—Usual method of holding Syme's knife while cutting the soft parts.

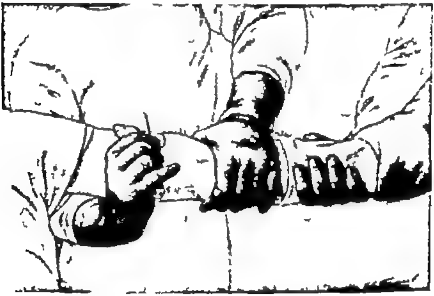


Fig. 1347.—The tour de maître.

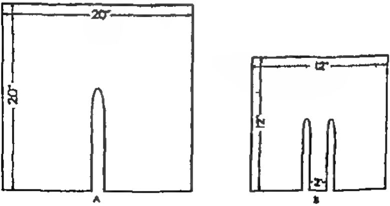


Fig. 1349.—Calico retractors. A, For the humerus and femur. B, For the forearm, or leg below the knee; the tongue of material is passed between the radius and ulna, or the tibia and fibula, as the case may be.

Ligation of Divided Vessels.—As many vessels as possible are picked up and ligated before compression of the main vessels is relaxed. A double ligature in the form of Ballance's stay knot (see p. 935) is recommended for the principal artery. After compression of the main artery has been released small bleeding vessels will be seen and secured.

Attending to Nerves.—Due largely to the use now made of *lateral* bearing appliances, in recent years there have been radical changes in the level of division of nerves during amputation. Unless an *end* bearing prosthesis is to be fitted, nerve-trunks should not be expressly sought, drawn down, and shortened as was formerly considered advisable. They are merely divided along with the muscles, with the result that amputation neuromata are less common.

Closure.—*The skin is approximated loosely with interrupted sutures, but correct apposition is important.* Dog-ears should never be allowed to remain. If such appear at the ends of the line of skin approximation, they should be snipped off with scissors and the resulting defect[1] brought together with a stitch. As a rule, if bleeding points have been attended to meticulously, drainage of the wound is unnecessary; the presence of a drain may interfere with the healing of the skin-flaps. It is also a possible source of infection. However, when oozing is troublesome a piece of corrugated rubber should be placed in one or both corners of the wound for 24–48 hours.

Unless there is some special reason for so doing, the stump should not be uncovered for fourteen days, when the stitches are removed. Often it is advisable to leave a few stitches in place for a further period.

SPECIAL EMERGENCY MEASURES

When it is essential to provide Free Drainage (i.e., infection is present).—

The guillotine amputation is not recommended; the only justifiable site for this procedure is in the lower third of the tibia, for here re-amputation at the seat of election (see p. 972) will be necessary in any case.

The usurper of the guillotine operation is the short, equilateral flap operation.

Fig. 1350.—When anteroposterior flaps are used, pocketing is encouraged.

Fig. 1351.—*Equilateral flaps afford the wound perfect drainage.* (*After W. A. Steel.*)

The wound is left partially or completely open. In the case of the femur or the humerus far better than anteroposterior flaps (*Fig.* 1350) are lateral equilateral flaps (*Fig.* 1351) which afford dependent drainage of the wound. In the case of the leg below the knee, and

[1] It is convenient to use one or both of the defects for the insertion of a drain, if that be considered necessary.

the forearm, lateral flaps are better avoided for the anteroposterior scar becomes drawn up between the ends of the bones. In these situations anteroposterior flaps are preferable. In either case having obtained good hæmostasis, the wound is packed lightly with petroleum-jelly gauze. In favourable cases, about the tenth day the flaps are drawn together with adhesive plaster or secondary suture is undertaken.

In the meantime skin traction should be applied (*see Fig* 1374 p. 980). If this is not done when the time arrives for the wound to be closed it will be found that the flaps and soft parts have retracted.

AMPUTATIONS OF THE LOWER LIMB

Disarticulation at the Hip-joint.—Amputation at the hip-joint is very rarely necessary in emergency surgery. I have performed the operation but twice as an urgent measure.

Position of the Patient.—The patient lies supine but slightly turned towards the sound side. The pelvis rests on the end of the table and the sound limb is secured to a leaf of the table (*see Fig* 13.4).

Stand on the outer side of the limb. The assistant supporting the leg must be fully acquainted with the meaning of the terms adduction and abduction and be able to execute these movements deftly when the order is given.

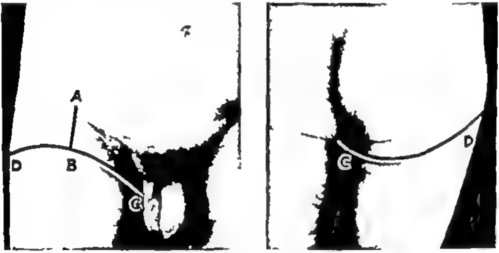


Fig 1352.—Incision for amputation at the hip-joint

Preliminary Ligation of the Femoral Vessels.—Make a vertical incision A–B (*Fig* 1352) 3 in. (7.5 cm.) in length in the line of the femoral artery. Ligate the femoral artery and vein.

Completing the Incision.—From the lower extremity of the vertical incision, sweep inwards along the line B–C to a point 4 in. (10 cm.) below the perineum. Then make the incision B–D which runs below the base of the greater trochanter. Carry the incision along the line C–D across the back of the thigh.

Dissect up the whole circumference of the skin and fascia.

Division of Muscles.—Direct attention to the outer side of the thigh. Divide the muscles right down to the bone. Tie the lateral circumflex artery. *Ask the assistant to elevate the limb.* Divide the insertion of the gluteus maximus and the muscles on the postero-internal surface. Try to find and ligate the medial circumflex femoral artery.

Tell the assistant to lower the limb to the horizontal plane and to *adduct and rotate inwards.* Divide all muscles attached to the greater trochanter. Tell the assistant to *abduct and rotate outwards.* Divide any remaining muscles.

The capsule of the hip-joint is now in full view. Open the capsule anteriorly with the amputation knife. Dislocate the head of the femur. Divide the remaining part of the capsule and the ligament of the head of the femur with strong curved scissors. The limb can now be removed. Proceed to unite the skin-flaps; it is surprising how readily

the posterior flap can be brought forwards. Drain the wound. *Fig* 1333 shows the end result in a patient who had the operation performed.

Amputation through the Thigh.—Through the thigh is an amputation often called for

Before the patient is taken to the operating theatre order the limb to be bandaged securely Say to the nurse "Make a parcel of this limb up to such and-such a level, and make certain that the parcel will not come undone In this way the infected area is isolated from the field of operation, which is shaved and otherwise prepared in the usual manner

Making Ready for the Amputation —If the end of the table has a leaf let it down. Have the patient's buttocks brought right down to the edge of the table Bandage the sound limb firmly to the leaf or leg of the table (*Fig* 1334).

If there is no contra indication to so doing elevate the limb and apply a tourniquet as far up as possible In other circumstances an assistant is relegated to the sole duty of applying digital pressure to the femoral artery or if an assistant capable of performing this duty is not available, there is no particular difficulty in modifying the operation so that when the flap has been raised the femoral vessels are unroofed, triply ligated, and divided between the lower two ligatures which have been applied sufficiently far apart for that purpose. Having draped the area surrounding the field of operation with sterile

Fig 1333.—Amputation through the hip-joint. The patient had a virulent osteomyelitis of the femur with infective arthritis of the knee in a limb deformed by old-standing infantile paralysis.

Fig. 1334 —Amputation through the thigh. The sound leg must be secured to the table A and B show the small guiding transverse incisions referred to in the text and in *Fig* 1335.

towels,[1] stand on the inner side in the case of the left leg and on the outer side in the case of the right. Ask the assistant supporting the limb to raise the leg. Make a small transverse cut in the skin on the *back* of the thigh at the level at which it is desired to divide the bone (*Fig* 1335 B). Have the limb lowered until it is in a straight line with the body. Make another small cut in the skin on the *front* of the thigh six or eight inches lower than the first (*Fig* 1335 A).

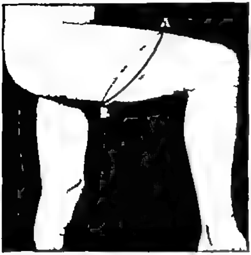


Fig 1335.—Incision for amputation of the thigh. A small transverse cut is mad on the back of the thigh at B which is the lev l at which it is proposed to section the bone. A small transverse cut is then made at A in front of the thigh, which is to be the extremity of the flap. A and B are now joined by an lliptical incision.

The Amputation.—Using an ordinary scalpel, describe an ellipse joining the two cuts just made. This incision is through skin and fascia only. Apply a Lane's forceps to the proximal side of the cut edge of the front of the thigh, and commence to dissect up the flap. Proceed to raise the skin and fascia only for a distance of about 3 in. (7.5 cm.). Now substitute the Syme's knife for the scalpel. Still raising the flap cut obliquely through the muscles of the front of the thigh in such a way that the flap contains more and more muscle. In this manner proceed for another 3–4 in. (7.5–10.0 cm.) until the level of the original skin mark on the back of the thigh is reached. With a stroke or two of the scalpel dissect up the skin for ¾ in. (2 cm.) on the back of the thigh. Clasping the Syme's knife with the blade looking towards one and the arm passed under the limb describe a tour de maître right down to bone. Make certain that all structures are divided (*Fig* 1336); particularly is this necessary in the neighbourhood of the linea aspera. Take a broad periosteal elevator and rapidly bare the bone as high up as can be reached with convenience. So firmly is muscle attached to the linea aspera that it is often necessary to exchange the periosteal elevator for a scalpel in this situation.

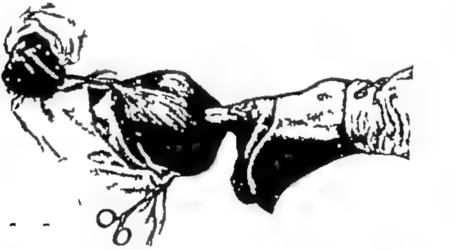


Fig 1336.—Amput tion of the thigh by Kocher method. The anterior flap has been turned p and the muscles t the back f the thigh ha been di ided.

Apply the cloth muscle retractor. See that the assistant has got a firm grip of the retractor with both hands, and i exerting sufficient traction to reveal the bone at

[1] A large sheet with a slit in the centre is con enient for draping the upper rt of the thigh and the trunk. The foot i passed throug the sl t and the sheet is carried up abov the knee to the desired level when the edges of the slit are clipped to the skin

the level at which it is to be sectioned (*Fig* 1337). With a Butcher's saw divide the bone in a strictly transverse plane The leg being amputated the second assistant dispenses with the muscle retractor grasps the stump and holds it in such a way as

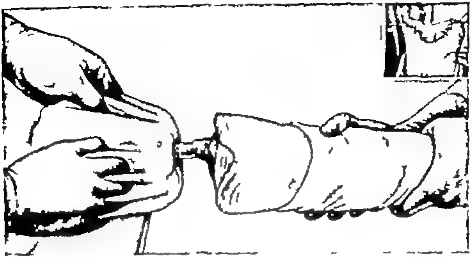


Fig 1337 —Amputation through the thigh. The retractor in position ready for the division of the bone *Inset* —The appearance of the stump at the completion of the operation.

to make the cut surface look upward. Doubly ligate the femoral vessels. Now ask the assistant to loosen the tourniquet or release pressure on the femoral artery Pick up bleeding vessels and ligate them, not forgetting there is sometimes an artery within the sheath of the sciatic nerve Unite accurately the deep fascia as a separate layer

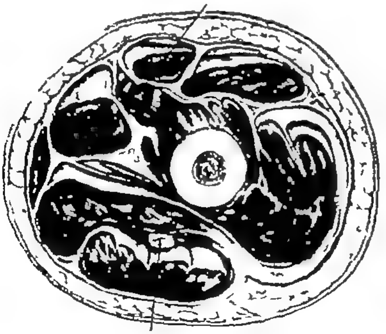


Fig. 1338 —Transverse section through the middle third of the left thigh.

and then approximate the skin margins with interrupted stitches. Insert a *strip* of corrugated rubber only if hematoma formation seems probable A light dressing is applied and held in place with adhesive plaster which is not applied tightly Bandaging has been abandoned because it tends to interfere with the circulation, *often impaired* already No splint or traction is applied

This amputation gives a well-covered stump with a *posterior* scar (*Fig* 1559).

Disarticulation at the Knee.—It is surprising that this amputation is not performed more often. Neither muscle nor bone is transected therefore the risk of spread of infection is minimized. There is less atrophy of the muscles of the stump than after amputation at a higher level consequently earlier fitting of a prosthesis (six weeks after healing) is possible. A prosthesis for this stump is comparatively easy to construct and to fit Gangrene of the foot spreading to the leg is a major indication for this operation, the only proviso being that sufficient viable skin must be available to close the stump In short disarticulation at the knee is a quick, safe easily performed non-traumatising operation eminently suited to the bad risk patient.

Fig 1559 —Amputation through the middle third of the thigh by Kocher's method. The stump.

Technique —When not contra-indicated, a tourniquet is employed. A long broad anterior flap measuring approximately one diameter of the knee at the level of the lower border of the patella, and a short posterior flap one-half of this diameter are fashioned, with the limits of the incision at the level of the condyles of the tibia (*Fig* 1300). The anterior incision is deepened through the deep fascia to the bone and this flap is dissected from the tibia and adjacent muscles, the insertion of the ligamentum patellæ and its medial and lateral retinaculæ being included in the flap The knee-joint having been opened, the medial and lateral ligaments are divided close to the tibia. The cruciate ligaments are severed close to the tibia, as also is the posterior capsule of the joint The medial popliteal nerve is identified, and hooked forward on the finger It is divided a few bundles at a time, so as to be enabled to identify and secure the accompanying artery The popliteal vessels are doubly ligated and divided in the manner described on p. 035 The biceps tendon is severed. The posterior flap is then

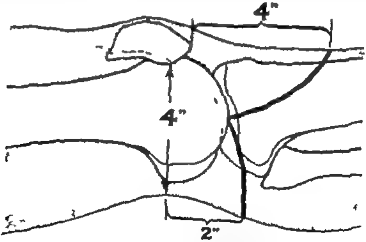


Fig. 1300.—Fashioning flaps for disarticulation of the knee-joint

dissected up The gastrocnemius, plantaris, and popliteus muscles are transected at a convenient high level The disarticulation is now complete Neither the patella, nor the cartilage of the condyles or of the patella, is removed

The tourniquet is released, and bleeding vessels are secured and ligated. The ligamentum patellæ is stitched securely to the cruciate ligaments and the remnants of the gastrocnemius muscle are also sutured to structures in the intercondylar notch. Corrugated rubber drains, which are usually necessary are placed in the corners of the wound.

The deep fascia and subcutaneous tissues of the anterior and posterior flaps are approximated with fine interrupted sutures. The skin is approximated, [illegible] being preferred by Colonel Batch and his colleagues, who have performed the operation twenty-six times.

Amputation of the Leg: the 6-in (15-cm.) Stump (the modern seat of election).—When contemplating a permanent stump, amputation through the *lower third* of the leg must be condemned wholeheartedly. The resulting stump is poorly nourished. It often becomes the seat of chilblains and it atrophies as age advances. The only justification for its employment is as a temporary measure in severe sepsis.

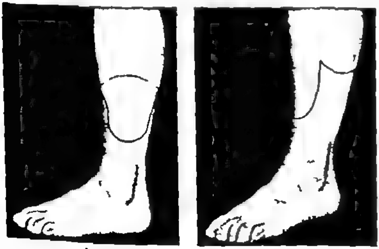
On the *other hand, amputation just below the middle of the leg* is free from these objections, and is, moreover, excellent from a functional point of view (*Fig* 1361). One should aim at leaving 6 in. (15 cm.) of the tibia and slightly less of the fibula. The 6-in. stump is so satisfactory from an artificial limb point of view that this is indeed the modern seat of election.

In urgent surgery amputation through the leg is most often required for crushing injuries. Attention has been directed to the advisability of resorting to primary amputation in cases of comminuted, compound, contaminated fractures communicating with the ankle-joint (p. 675).

A B

Fig 1361.—A, Amputation through [illegible] 6-in. stump. Undertaken for [illegible] volvement of the ankle-joint [illegible] an artificial limb fitted. The [illegible] wrote: "I hardly ever [illegible] with a slight limp as a man [illegible]

Technique.—Before the patient is taken to the operating theatre [illegible] securely in a sterile towel. As soon as he is anæsthetized the area of [illegible] washed [illegible] tourniquet [illegible] the thigh [illegible] some [illegible] doing [illegible] pressure [illegible] digital femoral [illegible] knee and [illegible] border of [illegible] guide [illegible] is marked [illegible] on the [illegible]



A B

Fig 1362.—Flaps for amputation of the leg. A, One long flap; B, A long anterior and a short posterior flap.

The Flaps. Flaps can be fashioned from healthy [illegible] haps the [illegible] anterior [illegible] equal. If one [illegible] flaps [illegible] failed [illegible] can be external [illegible] anterior it answers the purpose well. A *long anterior* and a short posterior [illegible] recommended (*Fig* 1362 B). When a single flap is used, care [illegible] make it too broad, otherwise when it is sewn into place a ridge [illegible] of the flap. To prevent other ridges forming the corners of the flap [illegible]

A good method of ascertaining just how much flap is necessary is to encircle the limb tightly with a length of suture material at the proposed point of section: this will register the circumference of the limb. With a little ingenuity it can be laid on the skin in such a way as to give an approximate idea of the size of the flap required. It is best to err on the side of having too much: it can always be trimmed with scissors before being sutured into place. Dissect up the flap—skin and fascia alone are required, though a little muscle may with advantage be included in the base of the flap.

Bear in mind that in this amputation there is always a tendency to sever the bones too high: therefore dissect up the flap until the base lies just distal to the scratch on the skin which marks the 6-in. level. Having pulled the flap upwards, perform a 'tour de maître' with a Syme's knife just a millimetre or two below the scratch on the skin. Cut right through the muscular masses at right angles until the bone is reached. Drive a long hæmostat through the interosseous membrane (*Fig.* 1363) and by its means bring the centre tail of the three-tailed calico retractor between the bones. The muscles are now held out of the way (*Fig.* 1364).

Division of the Bones.—The fibula is divided 1 in. (2·5 cm.) higher than the tibia. A frame saw may be used for the former or a pair of Exner's rib shears. The interosseous membrane should not be destroyed above the level of the division of the fibula, otherwise the end of the fibula tends to project forwards. The tibia is divided with a saw, after which the sharp cut end of the crest is sawn off obliquely (*Fig.* 1364—inset). Alternatively many maintain that it is easier to make the bevel cut first.

The tourniquet is now removed or the assistant releases digital pressure on the main vessel, and all bleeding points are ligated. The flap is then sutured accurately into place taking particular care to see that the deep fascia is united as a separate layer, using interrupted sutures; only when considered necessary on account of questionable subfascial hæmostasis is the wound drained with a strip of corrugated rubber.

Leg stumps should always be nursed on a back splint.

Below-the-Knee Amputation for Gangrene in a Diabetic.—There is weighty evidence to negative the teaching that an amputation through the thigh is essential in a diabetic patient with gangrene of the foot. For twenty-five years Chew Smith has advised a below-the-knee amputation, performed by the very special technique detailed below.

The foot and leg are prepared in the manner described: shaving must be conducted carefully, as skin cuts often become infected in these patients. Before the foot is done up into a parcel tinct. iodine is poured (not brushed) over the infected area.

Operation.[1]—Commencing 4–6 in. (10–15 cm.) below the tuberosity of the tibia, a straight incision is made down the middle of the subcutaneous border of the tibia for 4–6 in. The skin on either side of the incision is dissected up. At no time during the operation are forceps of any kind applied to the skin: if the skin is grasped by any instrument, areas of necrosis follow almost inevitably. The fascia on each side of the exposed tibia is incised, and with the finger or a periosteal elevator the investing muscles are freed from the tibia along the entire length of the wound. The interosseus membrane is pierced with a sharp periosteal elevator, and this also is separated from the tibia. Thus the tibia has been separated from all surrounding soft parts without entering the muscles. A Gigli's saw is passed beneath the tibia at the *upper* end of the wound. The soft parts are protected from the saw by abdominal retractors. The tibia is divided as water drips upon the bone. The lower divided portion of the tibia is drawn out of the wound. The most difficult step in the procedure follows—namely, division of the fibula. The bone is seated deeply when approached through this incision, and is surrounded by large muscle bellies laterally. It is more superficial in the lower part of the wound, where it is exposed by gentle retraction of muscles. The periosteum is incised and a short distance of the bone is cleared of periosteum, care being taken to avoid injury to the peroneal vessels posteromedially. The fibula is divided well below the tibia with the bone-cutting forceps, an endeavour being made not to splinter the bone. Both bones having been sectioned, the foot and lower leg are brought to a right angle with the upper part of the leg. The tibia has been freed from soft parts already, but the fibula must be denuded of its attached muscle with curved scissors directed towards the periosteum.

[1] During the operation the contralateral heel must be freed from all pressure, preferably by a foam-rubber pillow placed behind the tendo Achillis; otherwise the risk of gangrene of this heel is considerable.

Care must be taken not to sever the periosteum as this protects the peroneal vessels. Both bones, now divested of soft parts protrude from the wound. With the lower fragments held at *right* angles to the upper fragments, a circular incision is made around the

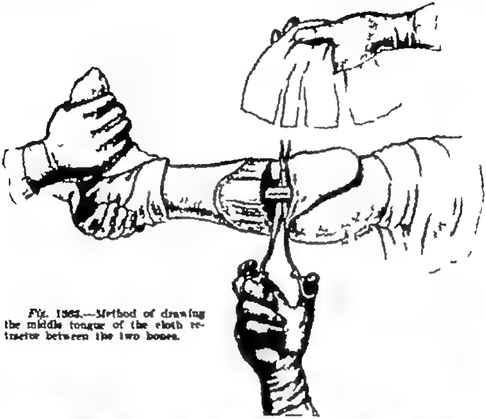


Fig. 1363.—Method of drawing the middle tongue of the cloth retractor between the two bones.

Fig 1364 —The 6-in (15 cm.) stump Dividing the tibia. *Inset.*—Method of bevelling the crest of the tibia.

limb at the level of the *lower* end of the longitudinal skin incision through skin, subcutaneous tissue and the deep fascia in one layer Veins are ligated, and the skin and fascia are dissected up as a flap from the muscles in an avascular plane for 1 in. (2 5 cm.).

A towel is placed on the upper skin flap, everting and protecting it and exposing the underlying muscle: the assistant's hand keeping it in place acts as a tourniquet. Traction is exerted on the foot held at right angles to the leg. A long amputation knife is placed posteriorly just below the skin flap, and all the muscles are divided at right angles. Vessels are secured and ligated: the cut end of the posterior tibial nerve should be examined, for sometimes there is a bleeding artery within its sheath. The protruding end of the fibula is grasped and its investing muscles are detached from the periosteum with scissors still further, again taking care to avoid the peroneal vessels. The fibula is re-amputated ½–1 in. above the tibia.

The sharp anterior edge of the tibia is bevelled: the wound is irrigated with 1–2 quarts (1–2 l.) of sterile saline solution. If hæmostasis is found not to be complete a corrugated rubber drain is placed in the posterior end of the wound. Through the drain is placed a safety pin, and to this is attached a silk ligature, so that the drain can be removed without disturbing the dressing. The wound is closed by interrupted stitches passed through the deep fascia. The closure of the skin is important: it is not touched with dissecting forceps, but grasped in gauze as the skin sutures are inserted. Petroleum-jelly gauze is placed over the wound and at the back of the leg, which is covered with fluffed gauze and then wrapped with wide gauze from a roll. Strapping extension is then applied to the skin of the thigh—a broad piece posteriorly and a narrow piece medially and laterally. These extend to 4 in. (10 cm.) below the dressing. Strips of adhesive plaster then encircle the dressing and the strapping extension. The entire dressing is encased in a sterile towel, kept in place by safety-pins.

When the patient is back in bed, the strapping extension is attached to a cord and a pulley screwed on to the bed rail: 2 lb. (900 g.) of extension is applied. This steadies the limb, relieves muscle spasm, and keeps the knee extended. If drainage has been used, the drain is pulled out of the wound without disturbing the dressing by means of the silk ligature described already. The stitches are removed on the tenth to the fourteenth day. As soon as the patient's condition warrants it, he sits in a chair without the traction, which is re-applied when he returns to bed.

Amputation through the Lower Third of the Leg.—A true guillotine amputation *through the lower third of the leg is a very useful and often a life-saving procedure*. It is seldom performed, but frequently indicated, in infected cases, particularly in the presence of a fulminating infection in an uncontrolled diabetic. A quick guillotine procedure removes the infected area, and facilitates control of the diabetes. It is a temporary expedient, and in successful cases must be followed later by an amputation at the modern seat of election.

Syme's Amputation is a good amputation for a man employed in heavy labour. After a Syme's operation many patients walk about the house without the prosthesis and suffer no discomfort. J. H. Shelswell, in a review of 303 Syme's amputations, many of which were for war injury, came to the conclusion that the Syme's amputee can do anything of which the below-knee amputee is capable, and possesses certain benefits that the latter does not possess. It is doubtful if its performance is justifiable in a female, for the prosthesis is inseparable from a conspicuously ugly ankle. Another disadvantage is that in some cases ulceration of the stump occurs after 10–15 years, if not earlier. However, patients prefer to have "ground sensation," even if it is only for a limited number of years. The results of this operation in children are especially good.

Fig. 1003.—Incision for Syme's amputation.

A specific indication for a Syme's amputation is if the other leg has to be amputated for trauma.

Technique.—The surgeon stands at *the end of the* operating table, facing the foot. If there is no contra-indication to so doing, a tourniquet is applied to the thigh. The foot projects over the end of the table.

First incision: The scalpel is entered below the tip of the lateral malleolus and carried downward, sloping somewhat toward the heel, across the sole, to end ½ in. (1·3 cm.) below the medial malleolus. Divide all structures down to bone.

Second incision: The two ends of the first incision are joined by the shortest route across the front of the ankle-joint. Divide all structures down to bone and open the ankle-joint.

Fashioning the flap: Divide the lateral and medial ligaments from their attachments to the malleoli. Dislocate the talus forwards by strongly depressing the foot. With a Syme's knife used with a sawing movement cut the calcaneus out of the heel flap from above (*Fig.* 1366) by working round the convexity of the heel in order to meet the U-shape incision on the sole. During this all-important manœuvre the watchword is—*keep close to the bone* otherwise the blood-supply to the flap will be imperilled.

The amputated foot is now removed and with a few cuts of the knife the base of the flap is dissected free from the back of the tibia and fibula.

Division of the tibia and fibula. The flaps are retracted. Make a circular incision through the periosteum at the level of the highest part of the articular surfaces of the tibia. The bones are sawn through at this point making sure that the cut surface is horizontal. "Unless a small portion of the articular surface of the tibia remains, the

Fig. 1366.—Syme's amputation.

section has been made too high" (G. Perkins). Remove with a saw any projecting portions of bone so as to render the cut surface smooth. As a rule a small portion of the edge of the fibula requires excision.

Vessels, nerves and tendons. Ligate the anterior tibial vessels and the plantar vessels. As the stump is to be end bearing, particular attention must be paid to nerves. Shorten the posterior tibial nerve, the anterior tibial nerve, the long and short saphenous nerves, and, if possible, the two divisions of the musculocutaneous nerve. The tendons are also pulled down and shortened. The tourniquet is now removed, and all bleeding points are ligated.

Bring forward the flap, which should form a complete cap over the ends of the bones, and suture it into place accurately. If there are any "dog ears" at the points where the original incisions met these should be removed with scissors. If necessary drain the wound posteriorly on the outer side. Dressings having been applied, a length of flexible adhesive plaster is affixed in the form of a U passing down the sides of the leg. This keeps the heel-flap in contact with the bone. It should be reapplied as necessary for three weeks. The limb is placed on a back splint of sufficient length to fix the knee and to allow the end of the stump to project beyond it for a few inches until the wound has healed.

Syme's amputation in two stages. A number of surgeons speak highly of Syme's amputation performed in two stages. The first stage consists of the operation as described

above up to the point when the foot has been disarticulated, blood vessels ligated, and nerves and tendons shortened The wound is then filled with petroleum-jelly gauze. The second stage is carried out when the danger of spreading infection has passed It consists of sawing off the malleoli and suturing the flap into position.

Transmetatarsal Amputation.—This has been found to give satisfactory results in selected cases of gangrene limited to the toes. Its main advantage especially in the elderly is that the patient can get about reasonably well with only the small alteration of filling the tip of the shoe with lamb s wool, to lessen the tendency of the shortened foot to slip forwards.

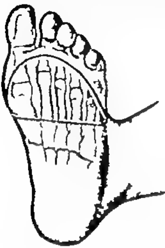


Fig. 1367 —Transmetatarsal amputation. The dorsal and plantar incisions.

Absence of palpable pulsation below the femoral artery is not a contra-indication to the operation, provided the skin of the dorsum of the foot is warm and well nourished. Infection must be controlled (*see* p. 938) before the operation is undertaken.

Removal of a toe, especially the great toe so alters weight bearing as to increase the vulnerability of the remaining toes. Bearing this in mind, the main indication for transmetatarsal amputation is gangrene of all or part of one or more toes. The operation is also indicated in crushing injuries involving the toes where primary or delayed closure can be accomplished at this level

The level of the amputation is just proximal to the heads of the metatarsals, and at the conclusion of the amputation for practical purposes there is only bone between the dorsal and plantar layers of the skin and subcutaneous tissue.

Technique —The dorsal incision commences midway between the dorsal and plantar surface of one side of the foot and with one bold incision down to the bone it is continued in a straight line across the dorsum to the midpoint on the opposite side The plantar incision commences at one end of the dorsal incision and runs parallel but 1 cm. proximal to the proximal crease of the toes (*Fig* 1367) This incision, likewise, must be made directly down to bone The comparatively long plantar flap thus obtained is dissected back to the level of the proposed bone section. The heads of the metatarsal bones, commencing with the first, are then removed with a saw The saw blade is allowed to rest against the previously cut metatarsal, which serves as a guide so an even stump is obtained. The plantar tendons and sesamoid bones are transected at bone level. Vessels having been ligated, closure (*Fig* 1368) is effected with non-absorbable sutures. The amputation should be conducted as atraumatically as possible At no time should the skin edges be touched with forceps. The flap is handled lightly with the fingers after it has been covered with moist gauze Dog ears must be excised as these will slough. A bulky dressing is applied to the foot and ankle being careful to pad the skin over the malleoli and the base of the fifth metatarsal the dressing is kept in place by adhesive plaster being careful to avoid pressure After the operation strict bed rest is maintained until the wound has healed, the head of the bed being elevated slightly At least half of the sutures must remain in place for two weeks, after which exercises of the leg are commenced.

Fig 1368.—Transmetatarsal amputation completed. (*After G. H Pratt.*)

A patch of gangrene of the skin, commencing particularly near the dorsal skin edge is a rather frequent complication. As a rule the area is small and separates spontaneously resulting in a granulating area which is likely to heal without skin-grafting Exceptionally progressive gangrene requiring re-amputation above the knee occurs.

Amputation of Toes.—In general, the principles set out in amputation of fingers (*see* p 000) can be followed, with two important exceptions. (1) No effort should be spared

to save the head of the first metatarsal (*Fig* 1369) this structure is of the greatest importance in the weight-bearing function of the foot (2) When it is necessary to amputate a toe for gangrene, the digit is removed by a racket-shaped incision. The long arm of the racket should be on the sole instead of the dorsum, so as to ensure dependent drainage. In order that there should be no pocket, this incision on the sole (*Fig* 1370) extends some distance towards the heel. According to circumstances the incision is closed, or filled with petroleum jelly gauze followed by secondary closure

Fig. 1369.—Amputation of the great toe, performed for laceration and crushing following a motor cycle accident. The head of the metatarsal has been preserved. Two years later the patient, a girl of 20 wrote to say "The loss of the toe is no inconvenience to me. I dance etc., as well as ever"

Fig 1370.—When amputating a gangrenous toe thought should be given to ensuring dependent drainage.

The skin of the dorsum of the foot is particularly vulnerable therefore it should never be picked up with dissecting forceps, or any other instrument.

When diabetic gangrene affects more than one toe of the same foot, and is strictly limited to the toes, there is much to be said in favour of amputation of all five toes at one operation. There is little added risk involved, and the patient is often spared a series of operations, each with its attendant dangers (W Oakley)

AMPUTATIONS OF THE UPPER LIMB

Considerable responsibility rests with the surgeon in advising amputation in the upper limb, for although improved greatly in recent years, the efficacy of an artificial arm[1] compares unfavourably with that of an artificial leg

Amputation at the Shoulder-joint.—Fortunately disarticulation at the shoulder joint is rarely required in urgent surgery Even two inches of the shaft of the humerus provides a stump to which an artificial arm can be fitted, but above this level the artificial limb can be but an ornament. If amputation at the shoulder is inevitable an effort should be made to leave the head of the humerus in the glenoid cavity This prevents the subsequent prominence of the acromion, which is unsightly and a nuisance to the patient.

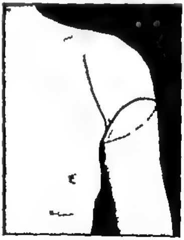


Fig 1371 —Incision for amputation at the shoulder joint.

Operation —Have the arm abducted and rotated outwards. Make an incision commencing at the tip of the coracoid process and passing downwards towards the junction of the pectoralis major with the humerus. The pectorales major and minor are divided, the axillary vessels found and ligated, and the main brachial nerves injected with 2 per cent procaine and divided. The arm is now encircled, as high as possible, by an incision through the skin and fascia (*Fig* 1871). Flaps are dissected up a short distance, then the muscles divided by the circular method right down to bone The outer flap which

[1] A mechanical hand with remarkable control has been devised at Roehampton, and many forearm amputees can hold their own with other light manual workers.

contains the deltoid is raised from the humerus with a knife. By rotating the arm in different directions, the muscles attached to the tuberosities can be made tense and divided. If it is absolutely necessary to remove the head of the humerus, the joint is opened. Otherwise the bone is sawn through at the anatomical neck. Modifications in the matter of skin-flaps may have to be devised to meet special circumstances (*Fig* 1372).

Amputation through the Upper Arm.—The site of election is 7–8 in. (17.5–20 cm.) from the tip of the acromion, or at least 2 in (5 cm.) above the epicondyle. Small equilateral flaps are fashioned, and unless there is some contra-indication one should be anterior and one posterior thus producing a transverse terminal scar. It is best to divide the muscles in two layers—first the biceps and triceps, and when these have contracted to complete the division of the deeper muscles to the bone. If transection of the muscle is not performed in this way the biceps and triceps retract far above the level of the other muscles. In the case of the upper arm when sectioning the bone very little if any retraction of the soft parts is necessary (*Fig* 1373). After vessels have been ligated, the deep fascia and skin are united as separate layers.

Fig 1372.—Patient after amputation at the left shoulder joint by modified posterior approach.

Fig. 1373.—Method of amputating the upper extremity by equilateral flaps and circular division of soft parts.

Amputation of the Forearm.—The site of election is not less than 6 in. (15 cm.) and not more than 7 in (17.5 cm.) from the tip of the olecranon. For reasons given on p. 976, the flap should be anteroposterior. Having divided the muscles, the three-tailed cloth retractor is employed, but again comparatively little retraction is necessary.

Amputations of the Fingers and Thumb are described in the next chapter.

AFTER TREATMENT OF THE STUMP

Especially in the case of an amputation through the thigh, the stump must not be propped with a pillow or a sandbag. Elevating the stump predisposes to permanent flexion deformity—a great disability.

Particularly in the case of the guillotine but also in other amputation stumps which have been left open, it is necessary to apply extension to the skin in order to aid the eventual healing of the stump. *Fig* 1374 shows the standard method of applying such extension. *Fig* 1375 is a good alternative.

For many weeks after an amputation stump has healed, œdema of the distal part of the stump interferes with the fitting of an artificial limb. The most effective and rapid method of combating œdema in this situation is by skilful crêpe bandaging (*Fig* 1376).

The care of each stump in this respect is described in the brochure *Rehabilitation following Amputation* published by the Ministry of Health.

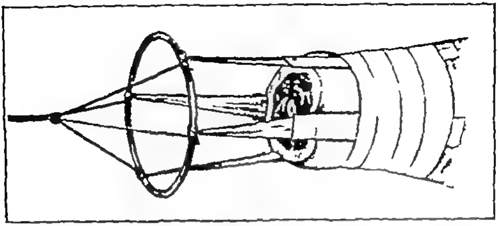


Fig. 1374.—Extension applied to the soft part of a stump by a metal ring and strapping

Fig. 1375.—In the absence of a metal ring a hoop of Cramer wire is an excellent substitute

Fig 1376.—Method of crêpe bandaging a thigh stump.

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CHAPTER LXXXI

LACERATIONS AND MUTILATIONS OF THE HAND

One third of all compensation cases concern the hand (A. E. Davis) and with the increase in factory employment this proportion is likely to become greater The social significance of hand injuries is apparent and equally apparent is the heavy responsibility on those often with limited experience called upon to treat these injuries.

The setting up of hand clinics has resulted in improved function after injury and the good results are indeed good. At the present time the majority of patients with hand injuries do not enjoy the benefits of such expert attention and this chapter seeks to guide those who treat such cases along the paths laid down by tested surgical principles.

PRINCIPLES OF EMERGENCY TREATMENT

The aim of treatment is first-intention healing whenever possible followed by an early restoration of function. Of paramount importance is the avoidance of infection, minimizing restriction of movement by scarring and the avoidance of joint stiffness. These principles underlie the procedures advocated below

First Aid.—First aid should be limited to covering the wound with a clean cloth or sterile dressing Bleeding rarely needs more than a firm bandage over wool for its control. Antiseptic lotions have no place in treatment—skin cannot be sterilized, and deeper tissues are easily damaged.

In the Casualty Department.—Attention here is limited to a brief appraisal of the nature of the injury The presence of shock or general disease is noted. A splint is indicated in cases of severe injury The Casualty Department is not the place for operative treatment—it is the most heavily infected part of the hospital, and it is wrong that the same hands that have just opened an abscess should operate next on a wounded hand. A patient with a lacerated hand should be admitted.

Diagnosis.—As always this rests on a history and clinical examination.

The history is important and the method of wounding must not only be noted but also recorded. It is sufficient to make a simple note, e.g., Whilst using a knife in the course of his work, the blade slipped and struck the back of his left index finger or Whilst using a grinding wheel at work to sharpen a chisel, the tool slipped and his right hand struck the wheel. The date of injury must be stated. Not only does the patient s statement assist in diagnosis but a record is made very shortly after injury that may support or destroy the patient s claims in litigation—which sometimes follows months or even years later Patients frequently are aware of the presence of a foreign body or sensory loss or tendon injury and their statements assist in the detection of these lesions.

Clinical examination must be local and general. The local examination appraises the nature of the injury the size and position of wounds, and the type of wound (e g incised, bursting). Movement, power and sensation are tested—and compared with the normal uninjured side if possible. Only thus are partial nerve and partial tendon injuries discovered. It is a good working rule to presume that all structures beneath a wound are damaged until the contrary is proved.

General physical examination is most important not only to determine fitness for anæsthesia but also to detect the presence of disease. A patient with a wounded hand may have syringomyelia disseminated sclerosis, or diabetes mellitus to mention only three diseases that are often late in being diagnosed. Such diseases predispose to injury and hinder recovery

In all cases where a fracture or a retained foreign body is suspected, an X ray examination of the part, in two planes at right angles to each other is indicated. In this connexion it should be remembered that certain plastic materials are not opaque to X rays, and that glass is only visualized if it contains lead.

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The Importance of Anatomical Exposure.—There need be no hesitation in enlarging wounds provided that certain principles are borne in mind. These are that incisions must not cross skin flexion creases, and that so far as is possible they must lie on skin which undergoes a minimum of movement.

Reference to *Figs.* 1379 and 1380 will indicate the approved incisions and how they may be used in enlarging wounds. It is worth emphasizing that good work can only be done through an adequate incision and the rate of healing of a wound does not depend on its length. The operator must see clearly what he is doing at every stage in the operation.

In this connexion some advise the routine use of a tourniquet in the shape of a sphygmomanometer cuff around the upper arm; any other type of tourniquet is liable to damage nerves (or blood vessels in the elderly) and is unsafe. The disadvantage of a tourniquet is that, owing to the absence of bleeding it makes the differentiation between dead and living

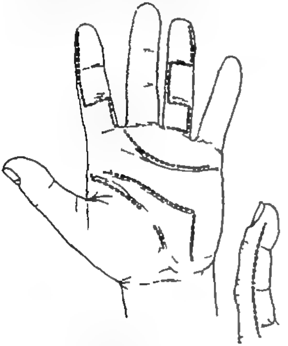

Fig. 1379.—Chart of incisions showing how they are made lateral in the digits, and follow the flexion creases.

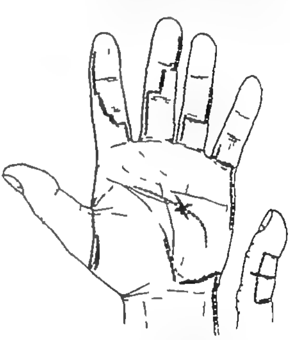

Fig 1380.—Chart showing how wounds can be extended by using the correct skin incisions.

tissue more difficult It also deprives the tissues of oxygen. This deprivation, even for a short time, is liable finally to kill tissue whose hold on life was definite, though precarious. *It is better to avoid using a tourniquet.*

Palmar Hæmorrhage.—*See* p. 949

Excision and Suture of the Wound.—This is the basic principle in the operative part of treatment. It aims at leaving a wound free of dead tissue and with its walls composed of living tissue adequately supplied with blood. This is based on sound pathology The removal of dead and damaged tissue deprives saprophytic bacteria of their habitat and results in a wound having living walls with a good blood-supply These factors are inimical to the growth of all bacteria, particularly anaerobes.

Technique.—The operation is performed with a scalpel and requires skill, practice, and a good light. Scissors, unless exceedingly sharp, are apt to crush the tissues they cut, and should be avoided. The layers of the wound, from the skin to its depth, are excised one by one until healthy undamaged tissue that bleeds normally is reached For the skin a shaving of 1 mm. thick is sufficient, but one should be more ruthless with fat. All damaged muscle must be excised: healthy muscle contracts when cut or pinched and bleeds freely Bone implicated in the wound should be scraped gently with a small curette.

Throughout the procedure the utmost gentleness is essential the objective is to remove dead and dying tissue with minimum trauma to the living tissue to which it is attached. To this end use sharp hooks, not tissue forceps, for retraction do not crush

TREATMENT

General Treatment.—This is directed against shock and infection. Shock is combated by the usual methods of relief of pain by morphine and splinting and by plasma infusion or blood transfusion if required. Infection is dealt with by the routine use of anti-tetanic serum (usually 1500 i.u. in adults, and half that dose in children) and the administration of antibiotics in adequate dosage (e.g. penicillin 500 000 units b d. by injection).

It is important at this stage to explain to the patient the nature of his injury the possible sequelæ (as far as is thought desirable), and to secure his permission for possible amputation if there is the slightest chance of this proving necessary.

Local treatment is directed towards the abolition of infection and securing, wherever possible, first intention healing.

Anæsthesia.—*A general anæsthetic* is usually desirable for seldom can the skin be cleansed properly without it; without meticulous skin preparation local anæsthesia is dangerous. Another disadvantage of local anæsthesia is that necessary enlargement of the wound is arduous, and, consequently, is inclined to be skimped.

Brachial plexus block is valuable, especially in cases of extensive injury of the hand where a time-consuming operation is anticipated.

Local anæsthesia (1 per cent procaine without adrenaline[1]) is satisfactory when the injury is confined to the distal half of a finger. The base of the digit is infiltrated thoroughly, the hollow needle being introduced from the dorsum (*Fig.* 1377). Be it emphasized that infiltration is performed slowly at the finger base so that the analgesic solution can diffuse in the loose interdigital space. No force should be exerted during

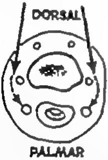

Fig. 1377.—Analgesic solution should always be introduced from the dorsal surface at the base of a digit, and without undue pressure.

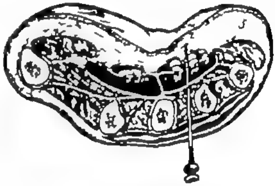

Fig. 1378.—Local anæsthetic being introduced from the dorsum to anæsthetize the palm.

the procedure and never inject with undue pressure on both sides of a phalangeal shaft; gangrene of the finger-tip has followed such injections as the result of excessive fluid accumulation compressing digital vessels between skin and bone. When it is desirable to employ local anæsthesia for a wound of the palm, again the anæsthetic solution must be introduced from the dorsum. Infiltration should be widespread, and it is quite an easy matter to infiltrate the subcutaneous tissues of the palm from the dorsum (*Fig.* 1378).

Preparation of the Part.—Dressings are removed from the wound in the operating theatre, and the surgeon, properly gloved and gowned, cleans the skin. A sterile pad is placed over the wound and the limb cleaned as far as the elbow with 1 per cent cetavlon, in abundant quantity. The limb is then dried and painted with surgical spirit. Neither of these substances should be sluiced over the wound as this carries infected material into it—hence the sterile pad over the wound.

This preparation completed, the surgeon changes at least his gloves, and drapes the parts in sterile towels. Most surgery of the hand is carried out conveniently with the abducted arm resting upon a table at the side of the operating table. This permits the operator to be seated, and allows a more meticulous technique. Good surgery is impossible if the surgeon is uncomfortable.

[1] The use of adrenaline in the anæsthetic solution often determines the onset of gangrene in cases where the blood-supply is imperilled.

2. Early Cases (i.e. within six hours of the accident).—

a. Incised Wounds are treated by excision and suture, as detailed already.

b. Contused Wounds.—When the skin edges are bruised wider excision of them is necessary. Frequently this results in a gap that cannot be approximated without tension, at least towards its centre. Tension (which deprives skin of its full blood supply) must at all times be avoided. As a rule it is possible to bring the extremities of the wound together without imperilling their blood-supply; if so this should be done. Covering the exposed area with split (partial thickness) skin-grafts is not difficult, is safe, and it is fairly certain that the graft will 'take'.

c. Penetrating Wounds.—Often the entry wound is small, but the subcutaneous damage may be great. Very careful clinical examination is necessary to determine the extent of nerve or tendon damage. The writer has seen a number of cases in which the deep branch of the ulnar nerve has been severed, and such damage has not been diagnosed. These wounds must be excised, enlarged as necessary, and explored thoroughly to their depths. Primary suture is then performed, as for incised wounds.

d. Bursting Wounds often go unrecognized as such. When a finger is severely crushed the sides of the digit split, permitting herniation of the pulp. When the terminal portion is involved there is often a subungual hæmatoma. Avulsion of the nail, or Kanavel's operation (see p. 1003), releases the hæmatoma, relieves most of the pain, and removes one favourite site for the growth of bacteria. When a finger has been crushed, dead and living tissues are so intermingled that they cannot be distinguished; consequently it is only possible to excise the edges of the skin. The wound is covered with tulle gras, splinted, and allowed to heal by granulation. Provided the blood-supply is unimpaired, the results of this treatment are excellent. On the other hand, as it is impossible to ascertain accurately the extent of the damage to the blood-supply, the unwavering rule should be that *primary closure should not be entertained in cases of crushing injury.*

Fig. 1382.—Deboned digital flaps were used to cover a skin defect on the dorsum of the hand. (Mr. T. B. Mouat.)

e. Wound with Loss of Skin.—Making a decision as to the best treatment of these injuries can be exceedingly difficult. The essential points to bear in mind are that the wound must be closed, that the best dressing is skin, and that the prevention of infection and the conservation of what healthy tissue remains is of paramount importance. A surgeon skilled in the transference of skin will know his limitations; for others the wisest course to pursue is the application of a partial thickness skin-graft cut with a razor or a knife. A Thiersch graft, which is purely epidermal, should not be used. The partial-thickness graft consists of epidermis and part of the dermis, and will 'take' in a very high proportion of recent wounds, provided it is placed on living fascia or muscle. It will not take on bare cortical bone, tendon, or joint capsule. After it has been applied it is covered with tulle gras and a pressure dressing, and the hand is placed on a splint. This type of graft has the disadvantage that it tends to contract and the area so covered is easily traumatized, although eventually considerable hypertrophy may occur. Its advantages are that it is simple to cut and apply, is of almost universal application, has a high proportion of success, and by providing a covering for the wound, prevents infection. Furthermore, it does not hamper any specialized repair work, if such is needed subsequently.

When considerable skin loss on the dorsum or the palm is associated with hopelessly crushed digits, the affected digits are disarticulated, but if there is a suitable portion of intact skin with a good blood-supply connected with the digit, it should be preserved and utilized to cover the skin defect on the palm or the dorsum of the hand (Fig. 1382).

Gatewood's Method of repairing a Wound with Loss of Substance on the Distal Half of the Flexor Surface of the Finger.—This method may prove useful, and Figs. 1384, 1385 make the principle clear. The difficulty of approximating the flap to the finger can be

bleeding points with hemostats and tie them off—use firm pressure with a gauze swab and all but comparatively large vessels will cease to bleed. Large vessels, of course must be ligated, but strangle as little tissue in the ligature as possible and cut the ligatures short so as to bury the minimum of foreign material.

If the foregoing instructions are followed meticulously the wound can be closed by skin sutures without drainage.

Further consideration of these principles will show that the object of the operation is to endeavour to obtain healing of the skin by first intention. As an emergency operation on an open, contaminated wound is not an occasion for extensive operative repair of nerves and tendons, this is deferred to a secondary operation performed after healing is complete.

The exception to this rule is if the wound has been caused by a reasonably clean and sharp implement and not more than four hours have elapsed since the accident. Then and then only can cut tendons be united with (preferably) fine stainless steel wire, and it is helpful to approximate severed nerves by a single stitch in order to prevent retraction and shortening of their proximal ends (R. G. Pulvertaft).

Splintage.—Splints are not required for fractures only: rest is also essential for the perfect healing of soft parts. Err, therefore, on the side of generosity in splintage and give these tissues every chance to recover. A plaster-of-Paris cast is the convenient means of affording rest to the hand, but whenever possible the fingers must be free to move. In cases where movement of the fingers is inadvisable, fear of stiffness need not arise if normal joints are immobilized in the position of rest (*Fig.* 1881) or in the position of function (*Fig.* 1882).

Fig. 1881.—The position of rest is the position adopted by the hand when it hangs limply by the side.

Fig. 1882.—The position of function is the position adopted by the hand in reaching out to grasp.

Those who hesitate to apply a plaster cast, and prefer to look at the wound every day or so, should remember that, unless carried out in the operating theatre, each dressing is a potential source of re-infection. If a patient with a wound under a plaster cast has no pain, is afebrile, and has no regional adenitis, then that wound must be progressing well.

When a plaster cast has been applied after the patient has been returned to his bed, the arm must be elevated. Once consciousness is regained, all parts not immobilized must be moved very frequently. It is the surgeon's duty to see that this is carried out. The more swollen the part, the more vital is the need for active movement. When not being exercised, the splinted hand must never be dependent.

The plaster cast should be taken off about ten days after operation, by which time the wound should be healed, and if so, the sutures are removed.

VARIETIES OF TREATMENT TO SUIT DIFFERENT TYPES AND CONDITIONS OF WOUNDS

1. Late Cases (i.e., more than six hours have elapsed since the accident).—The surgeon who closes a wound more than six hours old runs the risk of incurring severe infection of that wound. The wound must be excised: as a rule the amount of doubtfully viable tissue that must be removed is greater than that necessary in an early case. The wound should be covered with tulle gras and left widely open. If suppuration does not occur, secondary suture can be undertaken in suitable cases.

was begun two-and-a-half hours after the accident The hand was cleansed. A pocket was constructed in the thigh with divergent tunnels for the denuded fingers. Into the pocket was placed the hand, and the three injured fingers were drawn into the subcutaneous tunnels from counter-openings. Drainage was provided at the lower end of each tunnel and under the main flap. After the skin about the wrist had been approximated to the free edge of the flap the hand was firmly bandaged to the thigh. Drains were removed on the third day when it was apparent that there was no gross sepsis. One month after the original operation separation of the flaps was commenced. The fingers were separated one at a time the hand being completely freed on the 43th day (*Fig* 1388.)

Before commencing the implantation place the injured hand on the prepared thigh so as to make sure that the pocket will be in the right place. Construct diverticula for the fingers as divergently as possible (*Fig* 1389) so as to yield the maximal amount of skin for each finger Provide free drainage for the main flap and for each diverticulum.

Fig 1388.—Plastic surgery of the degloved hand. Condition at an early period after operation. (*British Journal of Surgery*)

Fig 1389 —The pattern for a subcutaneous tunnel for a degloved hand. The diverticula for the fingers and thumb should be made as divergent as possible. If there is a fair prospect of saving the remaining digits, the little finger should be amputated.

Replacement of a completely severed portion of a Digit.—The chances of survival of the autograft are inversely proportional to the length of time which elapses between the accident and the replacement of the fragment, and also to the amount of the contamination present. Amazing results have occurred.

T G Hamilton s Case —

A man, using a slicing machine, severed obliquely 1 in. (2 5 cm.) of the tip of his index finger Profuse bleeding caused much excitement in the shop and it was fully half an hour before the fragment was discovered with its cut surface against a cooked ham. The fragment was washed in saline solution and replaced Healing occurred by first intention.

Such a happy result is somewhat infrequent. If after forty-eight hours the fragment is becoming mummified or the suture line shows evidence of infection, the fragment must be cut away and the wound if infected, treated appropriately

Avulsion of the Terminal Phalanx with the Flexor Tendon.—

An engineer presented himself at hospital with the terminal phalanx of his thumb wrapped in a handkerchief. He stated that he had caught the thumb in revolving machinery To the severed phalanx 8 in. (20 cm.) of the flexor pollicis longus was attached (*Fig* 1390). The head of the proximal phalanx was excised after which the trimmed ends of the skin could be approximated. A very useful member resulted, for the short flexors of the thumb acted admirably

Fig 1390 —Avulsion of flexor pollicis longus.

COMPOUND FRACTURES OF THE FINGERS

The principles involved are the same as for compound fractures elsewhere—that is to say the fracture is converted into a closed one and then immobilized until union is sound.

overcome by inserting all stitches before they are tied. The resulting defect on the thenar eminence can be closed by interrupted sutures, or by split skin grafts (*see also* Chapter XCIII).

Figs. 1884 1885.—Gatewood's method of repairing a wound with loss of substance on the flexor surface of a finger

The Degloved Hand.—The patient gets his hand trapped. The skin and nails are torn off—indeed the skin has been literally ripped off the hand like a glove (*Fig.* 1886), and the muscles, tendons, and perhaps the bone, are laid bare. What is to be done?

When the Skin remains attached.—If there is a grey lifeless-looking mass of inverted and perhaps dirty skin hanging by a pedicle, it has been taught that the dying mass should be snipped away. C. Beck disparages this teaching for he has found that if it is cleansed and replaced skilfully the whole or the greater part of the skin often survives. Therefore when confronted with such a case excise lifeless pieces of muscle and fascia, dry the area, and replace the skin. Anchor

Fig. 1886.—The glove of a degloved hand.

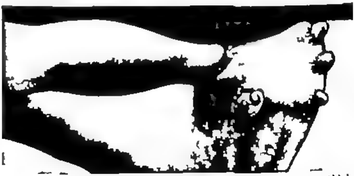

Fig. 1887.—A degloved hand embedded in the subsheath of the thigh. (*After W. E. Schroeder.*)

the skin here and there with sutures. Cover the area with tulle gras and apply a firm bandage. If a portion of the skin sloughs, after the infection has abated the defect must be made good by skin-grafting.

When the Skin is lost.—After thorough cleansing immediate implantation of the hand into the subcutaneous tissue of the thigh (*Fig.* 1887) or the abdominal wall may obviate the necessity for immediate or remote amputation. The results of the procedure are encouraging and hands or portions of hands have been saved which would otherwise have been sacrificed.

The late G. H. Colt's Case.—

A woman of 48 presented herself with a hand entirely denuded of skin on the dorsal aspect, and over the middle three digits and their metacarpal bones on the palmar aspect. Operation

Amputations of the Thumb.—The importance of the thumb as an integral part of Nature's pincers for grasping objects makes it imperative to conserve every portion

enormous grip between thumb & point
that I can climb a rope without

Fig. 1392.—By preserving the thumb and stump of one finger the patient is left with a useful hand.

possible. Even if we can only save a small part (*Fig* 1393), we have performed a great service to the patient.

In the endeavour to preserve as much as possible, denuded bone, if not grossly contaminated, may be covered by a flap from the contralateral forearm (see Cross-arm Bridge Flap, Chapter \CIII).

To show what conservative surgery will sometimes achieve the following case is quoted —

T G Hamilton's Case —

Whilst splitting wood a man severed his thumb completely near the base. It was attached only by some skin near the web The fragments were cleansed, and the divided flexor and extensor tendons were united. Stitches were also placed through the periosteum so as to co-apt the divided bone. The skin was then united by three sutures. After dressings had been applied the hand was encased in a starch bandage. The soft tissues atrophied and remained thus for a long time, but later they recovered, and for years the man has been working at his trade with very little handicap.

Fig 1393.—The hand of a patient who severed his thumb in a lathe. The stump, which is only ¾ in (2 cm.) in length, is of great use

Amputation of a Finger.—When deciding whether to perform partial or total amputation of the finger the major consideration is the patient's work. For one who earns his living by wielding a pick and shovel, or by comparable heavy manual labour the head of the metacarpal should be retained, unless there is insufficient flap or flaps to cover the end of the bone Loss of the head of the metacarpal reduces the effective spread of the palm and the ability to grasp On the other hand, a stump of a finger is an eyesore to the beholder while the absence of a finger passes unnoticed. \s a well planned total amputation leaves the patient with a hand which after a little practice is practically unimpaired (except in the matter of sheer strength), amputation of a single finger together with the head of its metacarpal is preferable to amputating the greater part of a finger in women (without exception), those who follow the learned professions business men clerks, and the majority of highly skilled workmen.

The wound is first excised and sutured. The fracture is then reduced by a combination of traction and flexion and immobilized on a splint in flexion. The flexed position maintains reduction, and should stiffness occur the finger is in a functional position. Beside flexion, the tip of the digit should point towards the base of the thenar eminence since if the fingers are flexed into the palm individually they will be found to point to this landmark.

For continuous traction in spiral or comminuted fractures, a pulp traction pin (Fig. 1391) is effective If used correctly it does not cause infection is not painful, and does not

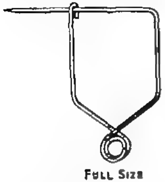

Fig. 1391 —Brock a pulp traction pin.

Fig 1392.—A, The direction of traction is shown The plaster does not extend beyond the palmar crease so that the metacarpophalangeal joints can be fully flexed. B, Traction in flexion reduces the fracture

damage the pulp Traction is maintained by a rubber band or fine rubber tubing, as shown in *Fig* 1392. The sites at which the pin passes through the finger are sealed with mastisol on wool (collodion does not bond with metal). It should be noted that the pin does not pass through the bone, and that the amount of traction needed is very slight. In the absence of a pulp traction pin one can be improvised from an intramuscular needle detempered in a flame so that its distal half is bendable (*Fig* 1393) A plaster cast over wool from the knuckles to the elbow is required for stability The free digits and the unencased part of the upper limb must be exercised frequently through

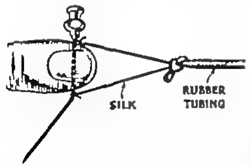

Fig 1393.—Method of improvising a pulp traction pin from an intramuscular hollow needle

their full range of movement After manipulation, the position of the fragments is checked radiologically at once and at weekly intervals for a fortnight Splintage is maintained until union is sound after which active exercises are essential In these compound fractures it is not uncommon for the tendons to adhere to the site of the fracture with permanent limitation of movement Perfect reduction minimizes this risk.

AMPUTATION OF DIGITS

Every surgeon is aware of the necessity for conserving the hand. Even the stumps of one finger and the thumb are more valuable to their possessor than an artificial hand (*Fig* 1394).

Amputations of the Thumb.—The importance of the thumb as an integral part of Nature's pincers for grasping objects makes it imperative to conserve every portion

enormous grip between thumb + joint that I can climb a rope without

Fig. 1394.—By preserving the thumb and stump of one finger the patient is left with a useful hand.

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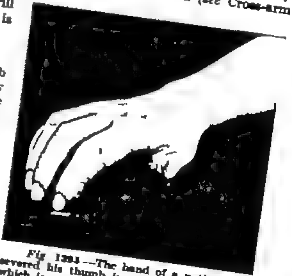

Fig 1393.—The hand of a patient who severed his thumb in a lathe. The stump, which is only ¾ in. (2 cm.) in length, is of great use

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Total Amputation of the Index or Little Finger.—The operation strongly recommended is Farabeuf's—that is, by a lateral flap.

We will consider the index finger. Commence the incision over the dorsal surface of the neck of the metacarpal bone. Sweep round in a curved manner to a point on the palmar surface diametrically opposite the commencement, the flap extending about a third of the way up the proximal phalanx. Dissect down this flap. Encircle the base of the finger with an incision passing through the first interdigital cleft (*Fig.* 1396). Now disarticulate the finger. After securing blood vessels, clear the neck of the metacarpal bone. Place the hand flat upon a side table and put a pad of gauze beneath the hand. Using a broad chisel, neatly and obliquely remove the head and neck of the bone (*Fig.* 1397). Suture the flap into position accurately. *In certain circumstances* it may happen that there is rather too much skin, in which case trim the flap before suturing. The result of this amputation is one of the most pleasing in surgery (*Fig.* 1398).

Fig. 1396.—Incisions for disarticulation at the metacarpo-phalangeal joint.

Fig. 1397.—Showing the method of sectioning the bone in total amputation of finger. In the cases of the index and the little fingers the bone is severed obliquely. In the middle and ring fingers the metacarpal bone is divided straight through the shaft.

Total Amputation of the Middle or Ring Finger.—A. P. Sherwood's method of reconstructing the interdigital cleft results in a most natural-looking hand. Inspect the webs on either side and select one to be preserved. Have the hand held in the manner shown in *Fig.* 1399. Commence the incision on the doomed finger to one side of the cleft to be preserved (*Fig.* 1400) and sweep down on the dorsal surface to about the middle of the metacarpal bone. Make a corresponding incision on the other side, only this time commence the incision at the base of the sound finger. Now turn the hand over and join the extremities of the incision in the form of a V (*Fig.* 1401). Return to the dorsum. Flex the joint strongly. Cut through the dorsal expansion, open the joint, and disarticulate the finger. Having attended to bleeding points, proceed to clear the upper part of the metacarpal bone and remove the distal half or rather more (*see Fig.* 1397), with a chisel and hammer (bone forceps are liable to splinter the bone). The skin edges are now sutured accurately into position. The interdigital cleft is thus brought into its new position. The hand is bound to a plaster slab the same width as the narrowed palm.

An important detail in the operation is the removal of the V-shaped wedge on the palmar aspect (*Figs.* 1401, 1402), which prevents the bulging pad that is so much in evidence after the usual racket removal of a finger. This pad, which is rich in nerve-endings, when subjected to any pressure, calls up a stiff, electrified ghost of the missing finger, a fault which is eradicated by employing Sherwood's technique.

Amputation of a Terminal Phalanx.—When a terminal phalanx is mangled disarticulation at the distal interphalangeal joint is indicated The well known classical method of removing the terminal phalanx by introducing a narrow bellied finger knife

Fig 1398.—Result of amputation of the index finger with excision of the head of the metacarpal. The U-shaped flap was used.

Fig. 1399.—Preparing to amputate at the metacarpo-phalangeal joint. Note that the healthy fingers are held aside by the assistant.

into the joint from the dorsal aspect and cutting so as to form a palmar flap (*Figs* 1403, 1404) is very seldom applicable for the pulp of the finger is crushed. On the other hand, small palmar and dorsal flaps of undamaged skin can usually be dissected up If after disarticulation it is found that the flaps are too short to cover the ends of the bone, the head of the second phalanx can be nipped off with bone forceps.

Amputation at the Proximal Interphalangeal Joint or through the Shaft of the Second Phalanx.—As, invariably amputation at either of these sites is necessary because of a

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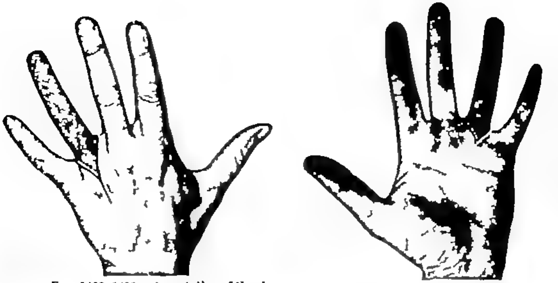


Figs. 1400, 1401.—Amputation of the ring or middle finger with reconstruction of the interdigital cleft (Sherwood's method).

Fig. 1402.—End-result of a total amputation of the middle finger. The patient suffers no inconvenience.

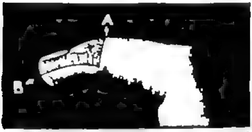


Fig. 1403.—Amputation of the terminal phalanx. An incision is made at A and the joint opened. After turning the knife through a right angle the manœuvre is continued until the blade emerges from B.

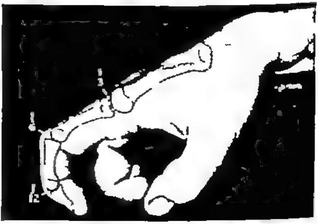


Fig. 1404.—It is important to realize that the joint lies $\frac{1}{4}$, $\frac{1}{6}$, and $\frac{1}{12}$ of an inch (6, 4, and 2 mm.) *distal* to the corresponding eminence or knuckle.

crushing accident no precise details can be given for cutting flaps. One simply fashions flaps of sufficient dimensions to cover the end of the bone from any available healthy skin. If these prove to be inadequate a suitable portion of bone must be removed with bone-cutting forceps. Particularly in the cases of the middle and ring fingers amputation through the interphalangeal joint results in a useful digit for a manual worker

CLOSED CRUSH INJURIES OF THE HAND

Crushing injuries in which the tissues are infiltrated with blood and the tissue spaces distended by hæmatoma, are crippling injuries. Much fibrosis occurs, and this limits

Fig 1405.—The hand is packed with wool, which is used also to separate the adjacent skin surfaces of the digits.

Fig 1406.—More wool is packed around the hand, and the whole is surrounded by a crêpe bandage and flexible adhesive plaster The method of suspension is shown.

tendon and joint movement. Such recovery as may occur is often incomplete and the process extends over many months.

Recently with a view to reducing the fibrosis, the writer tried the following régime the hand is moulded into the position of function, padded with plenty of wool (*Fig* 1405) and tightly bound with a crêpe bandage so that the dressing resembles a boxing glove The limb is elevated (*Fig* 1406). From the anti-inflammatory point of view cortisone therapy is helpful. A good and safe method of administration is prednisone, 40 mg for 5 days, 30 mg. for 5 days, and then 20 mg for 5 days, which concludes the course.

In these cases the relief of pain was dramatic having subsided completely in forty-eight hours, even on passive movement. These patients regained full range and power in all joints of the hand in 4 weeks. The method is worthy of an extended trial.

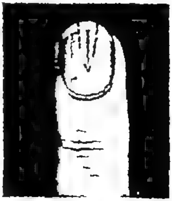


Fig. 1407.—A wedge-shaped piece of nail should be removed to give access to a foreign body beneath the nail.

SPLINTER BENEATH THE NAIL

So often failure to remove the foreign body or a part of it results in infection. The following simple and regularly effective measure should be adopted in all cases. The base of the finger is infiltrated with local anæsthetic A tourniquet applied by winding a catheter firmly around the finger from the distal to the proximal portion, and there

anchoring the catheter by a hæmostat after which the distal portion is unwound, greatly facilitates the removal of a small foreign body which does not become obscured by blood. These preliminaries having been completed a wedge of the nail overlying the splinter is excised (*Fig* 1407) This permits indisputable access not only can the foreign body be removed easily but the wound can be cleansed and dressed

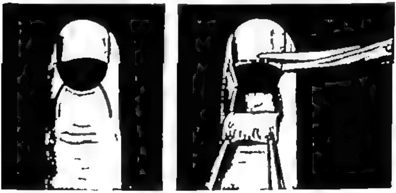
Needle in the Hand.—*See* Chapter LXXXVII p 1029

SUBUNGUAL HÆMATOMA

This common lesion is too often regarded as a triviality unworthy of surgical attention. There are many reasons why a hæmatoma under the nail should be decompressed and the blood evacuated. *Pain is relieved almost immediately* the danger of infection is minimized very considerably and an unsightly black nail that will be with the patient for many months is prevented.

First of all an X ray examination is desirable. In one-quarter of cases the terminal phalanx is fractured (M Iselin) It is a good practice to administer tetanus antitoxin because several cases of tetanus have been reported following this lesion.

Fig 1408.—Trephining the nail to evacuate a subungual hæmatoma.



A B

Fig 1409 —A, Incision for evacuating a subungual hæmatoma. B Excision at the base of the nail.

Evacuation of a Subungual Hæmatoma should be undertaken more frequently than is the case

Method 1 is suitable for early cases without considerable contusion of the nail-bed. In many instances the operation can be undertaken without anæsthesia, but if the finger is very tender it is wise to infiltrate the base of the digit as described on p. 992. A straight triangular pointed needle as used for stitching skin, or a very fine-pointed narrow scalpel is taken, and with a rotary motion, employing very little pressure a hole is drilled in the nail just above the quick (*Fig* 1408) This permits the blood to escape

and by squeezing gently all the blood can be evacuated. A small piece of gauze followed by flexible adhesive plaster are so applied as to exert moderate pressure

Method 2.—In later cases, and in those where there is considerable contusion of the nail bed and the nail will almost certainly be discarded eventually as a natural process, Kanavel's operation (*Fig* 1400) is admirable

See also Chapter XCIII

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Assistant Consulting Orthopaedic Surgeon Ashford Hospital Middlesex

CHAPTER LXXXII

INFECTIONS OF THE HAND AND FOOT

INFECTIONS OF THE HAND

In fully 80 per cent of cases the infecting organism is a *Staphylococcus aureus* which by its powerful exotoxin, causes early death of tissues. Sloughing occurs particularly in the fibro-fatty subcutaneous tissue of the pulp space of the fingers, and in the palm.

In 30 per cent of cases there is no known injury.

GENERAL PRINCIPLES IN TREATMENT

Physiological Rest.—In all cases rest to an inflamed hand should be insisted upon. For ambulatory patients a light plaster slab moulded to fit the volar surface of the hand

Fig. 1410.—Plaster slab for immobilisation of the hand. (*Mr. T. G. Lowden.*)

and forearm (*Fig.* 1410), cannot be bettered. In addition, in order to lessen œdema, the forearm is supported in a sling as high as possible towards the opposite shoulder.

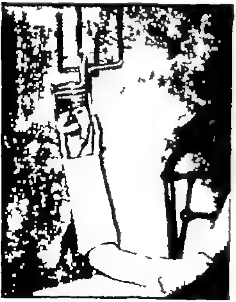


Fig. 1411.—The bandaged arm suspended from an irrigator stand.

For in-patients a Cramer wire splint, which is suspended readily (*Fig.* 1411), is most efficient.

Elevation of the Arm, by decreasing œdema, lessens throbbing pain. Œdema is a striking feature in all serious infections of the hand, irrespective of the site of the lesion; it is always greatest at the back of the hand. As it is a potent cause of subsequent stiffness of the hand, it is highly important that œdema should be controlled by posture.

These instructions concerning elevation do not apply in cases of uncomplicated paronychia and minor superficial abscesses: for these an ordinary sling is all that is required.

Anodynes.—In serious infections of the hand, in spite of elevation, drugs are required to relieve the pain. Tab. codein Co. 10–15 gr. (0.65–1 G.) repeated if necessary often meets the case.

Antibiotic Therapy.—Except in trivial infections, antibiotic therapy should be given without delay. *Penicillin is still the antibiotic of choice* because in about 93 per cent of cases the original infection is due to a penicillin-sensitive staphylococcus or streptococcus. However, the number of penicillin-resistant strains of these organisms is increasing and is especially *high in infections acquired in hospital.* Therefore if penicillin-resistance is suspected—and it should always be suspected in a case of anyone working within the precincts of a hospital—

while awaiting bacteriological confirmation another antibiotic, such as one of the tetracyclines, should be substituted. Antibiotic therapy is given in three sets of circumstances —

a In very early cases, the aim being to abort the infection. Should the inflammation, particularly the swelling, show signs of regression, daily injections are continued until resolution occurs.

b. In serious infections with considerable constitutional symptoms. Several hours, sometimes up to 24 hours or more in patient treatment including antibiotic therapy is given before the most opportune time for operation (if such be required) arrives. Whether operation is performed or not antibiotic treatment is continued until at least 24 hours after the temperature and pulse-rate have become normal It should be noted that conservative measures are employed during the stage of cellulitis which precedes abscess formation in many of the conditions to be described. It must also be realized that antibiotics can, by subduing local reaction modify the signs of inflammation but when pus is present acute local tenderness is always in evidence.

It is futile damaging, and often disastrous to rely on antibiotics alone when suppuration has occurred. If there is pus in any part of the hand, it must be evacuated.

c. Pre-operatively —In the majority of cases of infection of the hand, by the time the patient seeks advice, pus is present. Penicillin ½–1 mega unit (usually the larger dose) is then given intramuscularly three-quarters of an hour before operation Further similar injections of ½ mega-unit are given on the first five post-operative days in the case of out patients, while in patients receive the dose 6-hourly as long as is considered necessary

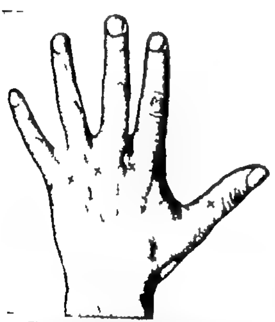


Fig. 1412.—Sites for injecting local anaesthetic in the case of the fingers. The illustration also shows the site for the lateral injection of the thumb

Cleansing the Area of Operation.—1 0 per cent aqueous solution of cetrimide applied with sterile gauze is satisfactory for this purpose.

Anaesthesia.—For the distal two-thirds of a finger or the thumb regional anaesthesia with 2 per cent procaine or xylocaine[1] is excellent

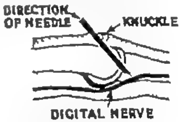


Fig 1413.—Showing the *modus operandi* of injecting a digital nerve. (*After P E B Holmes and D J J Graff*)

Step 1 —The dorsal skin between the knuckles is stretched, and after raising a weal, a fine hypodermic needle is introduced at a point shown in *Fig* 1412 Steadily injecting the anaesthetic solution, the needle is advanced distally and forward keeping fairly near to the proximal phalanx until it is judged that the digital nerve (*Fig* 1413) has been reached. Three-quarters of a ml. is deposited here.

Step 2.—The needle is then withdrawn as far as the subcutaneous tissue. While injecting more anaesthetic solution, its point is then advanced in the subcutaneous tissue across the knuckle as far as the contralateral interdigital cleft. In this way the dorsal nerves and the site of injection of the opposite side of the finger are anaesthetized. The needle is then withdrawn completely

Step 3.—The deeper tissues and the nerve are infiltrated on the contralateral aspect of the affected finger

[1] Xylocaine—Duncan Flockhart & Co. Ltd., Wheatfield Road, Edinburgh, 2.

In order to distribute the anæsthetic solution more rapidly 300 i.u. of hyaluronid can be added to 50 ml. of the anæsthetic solution[2] (usually supplied in a rubber-ca bottle). The hyaluronidase also promotes rapid absorption of the combined inflamma and injection œdema (Catchpoll and Lunn).

In the case of an abscess of the hand proper full general anæsthesia is required. no account should a short anæsthetic, e.g., nitrous-oxide gas, be employed. Com muscular relaxation and an unhurried operation are essential if the mistakes of the are to be avoided

A Bloodless Field must be insisted upon Only under these conditions can the e site and extent of the lesion be determined, and damage to tendon-sheaths and ne be avoided. The cuff of a sphygmomanometer is applied to the upper arm. The lin then elevated for two minutes, after which the bag is inflated to a pressure of 200 mm.

Instruments required for operating upon an infected hand are few but shoul delicate (*Fig* 1414).

Operation is undertaken at a time when there is a high penicillin level in the bl With the possible exception of tendon-sheath infection, it is insufficient merely to evac pus. The operation must be me lous. Slough must be removed necessary it is cut away) and, i is extremely important all gra tion tissue lining the abscess ca must be thoroughly abraded by g (usually the preferable method) scraped away with a curette.

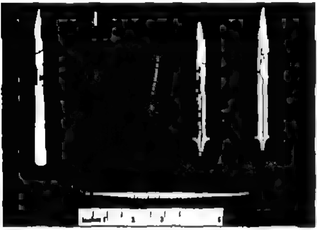


Fig 1414.—A fine-pointed scalpel, toothed and non-toothed dissecting forceps, fine pointed scissors (straight and curved on the flat), a Watson-Cheyne dissector and a small curette (not illustrated) are the only instruments required for operating upon infections of the hand

The curette certainly shoul avoided in the vicinity of vulner structures such as the periosteum the sheath of a tendon. Only i granulation tissue has been remo leaving the walls of the abscess ca clean *and oozing blood*, will penic from the blood enter the cavity fr Provided granulation tissue has l removed from every nook and cra of the cavity it is unnecessary indeed harmful, to employ drai material, for no further pus is expe to form; a little serum contai at first blood, and perhaps a few dead bacteria, is all that oozes from a cavity thus trea The exudate lessens in amount about the third day when quick healing is to be expect

After treatment.—Dry dressings are employed. The dressing is changed 24 h after operation, when dry gauze, followed by a little wool, can be covered by a viscop bandage . Thereafter often an interval of two days can elapse between the redressi Great care must be taken to prevent secondary infection during redressing The pat is instructed not to get the dressing wet. This rule differs only in the case of paronyc in this instance the patient is instructed to wash his hands frequently dry them thoroug with a towel kept for the purpose, and to reapply the dressing himself. Physiother and exercises form an important part of late after treatment of the more serious ty of infection of the hand.

Continued Suppuration.—Provided the principles of treatment set out above h been followed, continued suppuration is uncommon If it occurs, the first considera in most situations is the possibility of extension of the infection to another fascial sp or in the case of a tendon-sheath, to the ulnar bursa (see p. 1018). Necrosis of bon another cause of continued suppuration, clear radiographic evidence of which is present until the fifth day or later In relevant cases the possibility of a retained for

[1] Hyalase—Benger Laboratories Ltd., Holmes Chapel, Cheshire.

[2] The mixture must be stored in an ordinary refrigerator to prevent deterioration of hyaluronidase

ody should be borne in mind. Sloughing tendon is a potent source of prolonged uppuration.

LYMPHANGITIS

Superficial Lymphangitis is the more common variety and the organisms (nearly lways streptococci) gain entrance through an abrasion that may be microscopical Within a few hours the adjacent portion of the hand becomes swollen and painful, and here is often considerable elevation of the temperature. Because superficial lymphatic essels pursue the shortest course to he dorsum, œdema which comes on arly is most in evidence in this situation (*Fig* 1413) A little later red treaks, so characteristic of lymphangitis, can be seen coursing up the arm. Especially in lesions of the ulnar half of the hand, the first lymph-node to become enlarged and tender is the supratrochlear In a few instances of nfection entering the middle finger the irst lymph-node to become enlarged is above the clavicle, in which case infection is liable to enter the general circulation and give rise to severe constitutional symptoms. The lymphatics of the thumb and index finger pass straight to the axillary nodes. Lymphangitis can occur without demonstrable lesion, or as an accompaniment of one of the entities to be described, particularly terminal pulp-space infection and fulminating tenosynovitis.

Fig 1413 —Œdema of the dorsum, which is often present in infections of the hand, gives rise to swelling that pits on pressure

Deep Lymphangitis.—In deep as opposed to superficial lymphangitis, there may or may not be red streaks passing up the arm. In their absence the diagnosis of deep lymphangitis can be assumed only by a series of negations—there is no pain or limitation of movement when the patient is asked to move the fingers there is an absence of pain on hyperextension of the fingers and thumb, an absence of tenderness over the tendon-sheath, and absence of bulging of the palm and an absence of tenderness over the middle palmar and thenar spaces. After all these points have been ascertained with negative results, there follow two affirmations—the constitutional symptoms are considerable and there is usually a rapid and striking increase in the swelling of not only the back of the hand, but the whole hand and forearm.

In all cases of lymphangitis the treatment is penicillin therapy and rest to the inflamed limb.

CELLULITIS

Cellulitis is the initial lesion of the fascial space infections about to be described. In a proportion of cases, which is higher in loose subcutaneous spaces than in those more confined, the inflammation resolves. In the remainder a localized abscess forms.

Incision during the stage of active cellulitis is highly mischievous. On the other hand, it is emphasized that fluctuation must not be awaited in infection of closed and deep spaces. Swelling, induration, and localized tenderness constitute a triad of signs that indicate that the time is ripe for operation.

SUPERFICIAL ABSCESS

A superficial abscess of the hand can be —

a. Intradermal (purulent blister)

b. Subcutaneous.

c The superficial loculus of a collar-stud abscess.

The volar surface of the hands of manual workers is often covered with greatly thickened epithelium. In these circumstances a subcutaneous abscess may burst through

the dermis and extend in the layers of the epidermis, in which event it is impossible t differentiate it from a purulent blister until the deeper loculus has been discovered a operation. This variety of collar-stud abscess is also encountered frequently in the pul of the fingers and thumb.

CARBUNCLE OF THE HAND

A carbuncle is common on the dorsal aspect of the proximal segments of the digit and on the dorsum of the hand. It is much more often encountered in males th females, because in the male these areas are often hairy The carbuncle is liable t involve the extensor tendon, and is slow to heal. The treatment of carbuncle is discuss on p 123.

PARONYCHIA

Paronychia is the most common infection of the hand (30 per cent) Organism usually staphylococci gain entrance through a hang-nail or an abrasion of the nail-fo during manicure The inflammation commences as a subepithelial infection of eith the nail fold or the lateral sulcus (*Fig* 1416) When seen within 24 hours of the onse it is possible that the infection may be aborted by rest and ant biotic therapy In most cases, however by the time the patie presents, pus is present. Confined by the adherence of th eponychium to the base of the nail, the pus tracks around th cutaneous margin. In a high percentage of cases it undermin the proximal part of the nail and separates more and more of th nail from the subungual epithelium. In about one-third of u treated cases the more superficial part of the abscess ruptures, b suppuration continues, and not infrequently the abscess cavity becomes secondarily infected with *Bact. coli* and other organisms.

Fig 1416.—The parts concerned in paronychia.

Operation.—Commencing with the handle of a scalpel, and continuing with a Watson-Cheyne dissector the eponychium is pushed back from the base of the nail, as in manicure. Once adherent cuticle is separated from the nail the eye of a straight needle is used to break down the epithelium covering the pus. If gentle pressure is exerted over the nail, exit is also given to a subungual extension if such be present. All remaining pus is removed by packing wisps of gauze into the crevice and then discarding them. Redundant cuticle is cut away with fine-pointed scissors (*Fig* 1417 A). Should there be a pocket under the corner of the nail-fold (and this point must be ascertained by probing) a tiny wedge of overlying skin is removed (*Fig* 1417 B). If the pocket extend beneath the nail a corner of the base of the nail is clipped off Only when pus has extended beneath a third or more of the width of the nail is excision of the proximal third of the nail required (*Fig* 1417 C).

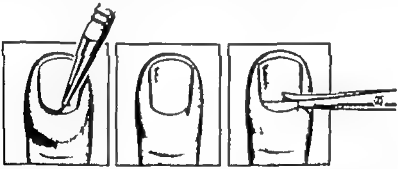


Fig 1417.—A, Excising the eponychium; B Pocket unroofed, when such is present C E cising the proximal third of the nail (hana cf operation) (see text for indications)

THE TERMINAL PULP SPACE

The pulps of the fingers and thumbs are subjected to more pricks than any other part of the body Infection of the terminal pulp space is second only to paronychia as

the most frequent infection of the hand. The index finger and thumb are affected most often.

Surgical Anatomy.—The deep fascia fuses with the periosteum just distal to the insertion of the tendon of the flexor digitorum profundus (or in the case of the thumb the flexor pollicis longus) The deep fascia is also attached to the skin of the distal flexion crease thereby closing the terminal pulp compartment at its proximal end (*Fig* 1418)

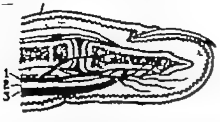


Fig 1418.—The terminal pulp compartment is closed proximally by the deep fascia. 1 Digital artery ; 2, Flexor tendon 3, Deep fascia. (*After Handfield Jones*)

Fig 1419.—The usual location of pus in the terminal pulp space.

The space is filled with compact fat feebly partitioned by fibrous septa. These septa play but little part in the limitation of infection. Through this space run the terminal branches of the digital artery to supply the distal four fifths of the terminal phalanx ; thrombo-arteritis of these vessels accounts for the frequency with which osteomyelitis complicates infection of this closed space

Clinical Features.—Dull pain and swelling are the first symptoms. By the third day there are severe nocturnal exacerbations of throbbing pain interfering with sleep. Light pressure over the affected pulp increases the pain. The corresponding supra trochlear lymph-node is frequently enlarged and tender If the pulp is indurated and has lost its normal resilience pus is present (*Fig* 1419). Untreated, the abscess tends to point towards the centre of the pulp beneath a patch of devitalized skin. A collar stud abscess then occurs still untreated the abscess bursts.

Conservative Treatment.—If the case is an early one (under 48 hours) penicillin treatment for 24 hours is advised, for on no account should operation be undertaken during the stage of cellulitis only if local improvement is undeniable should non-operative treatment be continued.

Operation.—A transverse incision is made through the skin at the point of greatest tenderness (*Fig* 1420). The beginner is warned not to be beguiled by entering the superficial loculus of a collar-stud abscess. Removal of the slough, which is frequently present, is essential great care must be taken not to traumatize the periosteum.

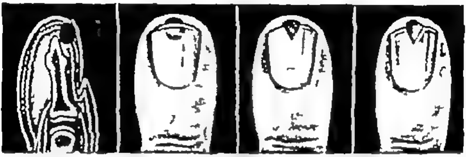
Fig 1421.—Osteomyelitis complicating infection of the terminal fascial space

Fig 1420.—Incision of an abscess of a terminal pulp space. (*H Bolton.*) (*Journal of Bone and Joint Surgery*)

Osteomyelitis of the Terminal Phalanx is all too commonly a sequel of terminal pulp-space infection. At operation, in a case of some standing, that part of the bone bereft of its blood supply (*see Fig* 1418) is sometimes found to be loose and can be lifted out of the abscess cavity at the time of the operation. More often the sequestrum separates (*Fig* 1421) some weeks after the abscess has been evacuated in which case the wound continues to discharge. Repeated radiographs and probing will indicate when the sequestrum has separated. Only then must it be removed, after which healing will proceed apace. In the case of a child, provided the periosteum is relatively undamaged, regeneration of the diaphysis is possible. In the adult no regeneration occurs, and the patient is left with a shortened terminal phalanx covered by an ugly curved nail.

THE APICAL SPACE

The apical space is situated between the distal quarter of the subungual epithelium and the periosteum (*Fig* 1422 A). Usually it becomes infected by running a sharp object under the free edge of the nail into the quick. The lesion, which is exquisitely painful gives rise to *comparatively little swelling*. *This* rather common condition is often confused with terminal pulp-space infection, but unlike the latter tenderness is greatest at or just beneath the free edge of the nail. Sometimes there is redness passing down one or both of the lateral nail folds, and even extending around the skin edge at the base of the nail paronychia is then likely to be diagnosed unless the area of greatest *tenderness is ascertained. Pus comes to the surface either just distal to or just beneath* the free edge of the nail (*Fig* 1422 B)



A B C D

Fig 1422.—A, B Location of an abscess of an apical space C, D, Method of treatment.

Operation.—A small V (*Fig* 1422 C) of the free edge of the nail overlying the site of greatest tenderness is removed, and a little wedge of the full thickness of the skin overlying the abscess is excised also (*Fig* 1422 D) The amount of pus and debris evacuated is surprisingly small commonly the abscess cavity extends down to the bone, but osteitis is most unusual. Following the operation, *relief of symptoms is immediate* and the wound heals in under a week.

INFECTION OF THE VOLAR SPACE OF THE MIDDLE AND PROXIMAL SEGMENTS OF THE DIGITS

These spaces *lie in front of the corresponding flexor tendon-sheath.*

The middle volar space is separated above and below by fibrous partitions while like its fellow it is shut off from the dorsal cellular tissue by fibrous septa extending from the skin and the periosteum.

Fig 1423.—An abscess of the terminal volar space usually points at the distal flexion crease while pus in the proximal space passes to an adjacent web space (*After M Iselin.*)

The proximal pulp space is well separated from the middle pulp space but below it communicates freely with the web space The fatty tissue occupying these spaces is packed more loosely than that of the terminal pulp space.

Diagnosis.—Infection of these spaces is fairly common. It may be subcutaneous or deep to the deep fascia. In the latter case, *especially when the middle segment is involved, the finger* is held in semiflexion and an attempt to straighten it is painful. While the whole finger is swollen and tender induration is confined to the affected segment In comparatively early cases differential diagnosis between infection of either of these spaces and localised infected tenosynovitis is sometimes so difficult that an exploratory operation must be performed. In late cases of suppuration in the middle segment a purulent blister appears frequently near the terminal flexion crease (*Fig* 1423), while in the proximal *segment* the swelling is asymmetrical because extension to the web space is frequent

Operation.—After pus has become localized and the diagnosis is not in doubt the best approach is through a transverse incision over the point of greatest tenderness. When the diagnosis is uncertain the space should be explored through a *lateral longitudinal* incision (see p. 1018)

WEB-SPACE INFECTION

The three interdigital web spaces are filled with loose fat that bulges between the three divisions of the palmar fascia (*Fig* 1424) When the space is filled with pus most of it lies on the volar aspect, but there is often an extension passing over the transverse ligament to a smaller dorsal collection. If it is allowed to do so, it is here on the dorsal aspect, where there is less resistance that the abscess points. Anatomically it is possible for pus in a web space to track along a lumbrical canal to the middle palmar space In practice it seldom does so. Infection of a web space often results from a purulent blister on the fore-part of the palm. It can also arise as an extension from an abscess of the proximal pulp space of a related digit.

Diagnosis.—Constitutional symptoms are usually severe ; consequently patients with this condition are often seen before localization of the infection has occurred. At this stage there is gross œdema of the back of the hand, and although web-space infection

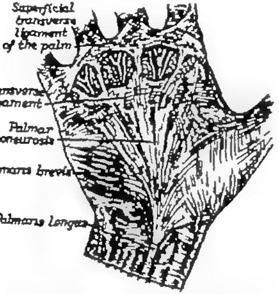


FIG. 1424.—The three interdigital web spaces situated between the transverse fibres of the palmar aponeurosis (transverse ligament) and the superficial transverse ligament separated by the slips of palmar aponeurosis. (*After P J Palmer*)

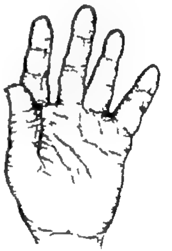


Fig 1425.—Infection of a web space

can be strongly suspected from the location of the tenderness, it is often difficult to rule out infected tenosynovitis. The patient should be put to bed with the arm splinted and elevated by suspension. Penicillin is administered. Once localization has occurred, the signs of infection of a web space become manifest In severe infections the involved fingers are separated (*Fig* 1425). In addition to the area of redness shown, there is often a fan-shaped blush on the dorsum extending from the web. The maximum tenderness is found on the volar surface of the web and at the base of one of the fingers extending a short way into the palm. There is often tenderness also on the dorsal aspect of the web. Untreated, pus can track across the volar surface of the base of a finger into an adjacent web space, and also up the sides of the proximal segments of the related digits.

Operation.—If there is an area of devitalized skin either anteriorly or posteriorly the abscess is entered by snipping this away In other circumstances a transverse incision is made on the palmar aspect, just below the web or just below the proximal flexion crease of the finger most affected whichever is the more indurated. A few strands of palmar fascia have to be divided. The walls of the abscess cavity which is often the size of a thimble are cleansed of granulation tissue. If, by gentle probing, a communicating channel is found passing to the dorsum, it is advisable to make a counter incision on the dorsal aspect. In either case the whole of the interior of the space must be denuded of granulation tissue.

INFECTIONS OF THE FASCIAL SPACES OF THE PALM

Superficial Infection has been described on p 1009

Subaponeurotic Infection.—Following pricks or splinter penetration, suppuration occurs occasionally in the space between the palmar fascia and the flexor tendon-sheath. In this situation collar-stud abscess formation is not unusual, the pus tracking through the original puncture in the palmar fascia into the layers of the skin (there is no subcutaneous space in the centre of the palm (*Fig* 1426))

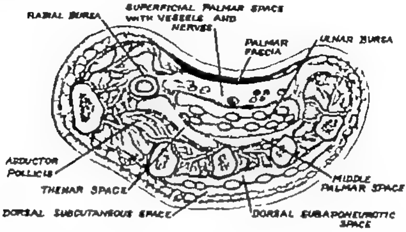


Fig 1426.—Cross-section of the middle of the palm.

Operation —In the case of both subcutaneous and subaponeurotic abscess of the palm, a small transverse incision is made in the line of the nearest skin crease over the most tender area or when pus can be seen beneath the thickened epidermis, the abscess is entered by paring away the superficial layers of the skin. The interior of the abscess cavity must be inspected and probed with accustomed care should an opening be found

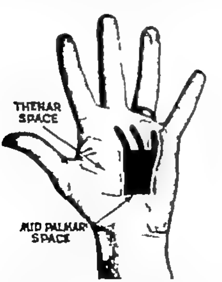


Fig 1427 —The relative positions of the thenar and middle palmar fascial spaces. Note the three diverticula (lumbrical canals) from the middle palmar space

Fig. 1428.—Incision for entering the middle palmar space

leading to a deeper collection it is essential to enlarge the opening sufficiently to be enabled to remove slough and infected granulations from its wall with strips of gauze

Middle Palmar Space Infection lies very deeply It is situated between the flexor tendon-sheaths and the fascia covering the interosseous muscles (see *Fig* 1426), being separated from the thenar space by a fibrous septum, extending from the palmar fascia

to the middle metacarpal bone (*Fig* 1427). Infection of this space, which is now rare, usually occurs via the lumbrical canals from rupture of an infected tendon-sheath of the middle, ring, or little finger. It gives rise to enormous swelling of the hand, which has been likened to a whale's flipper. Obliteration of the concavity of the palm with slight bulging thereof is almost pathognomonic of an abscess of the middle palmar space. Early in the condition the interossei, which are bathed in pus, become paralysed, as shown by the simple test of asking the patient to grip a card between the fingers held straight. After the space has been drained, these muscles slowly recover.

Operation.—The space is entered through a transverse incision in the middle third of the distal palmar crease (*Fig* 1428). The bloodless field permits precise access to the middle palmar space on either side of the flexor tendon of the ring finger; the radial side should be chosen, the better to avoid the ulnar bursa.

After pus has been evacuated, gauze strips are used to denude the walls of the cavity of granulation tissue.

When an empyema of the middle palmar space is associated with suppurative tenosynovitis with a sloughing tendon, Iselin has found that amputation of the affected finger together with the head of the metacarpal bone is the most satisfactory method of dealing with this complex situation.

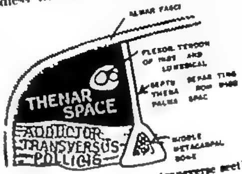


Fig 1429.—Diagram of a transverse section through the thenar space.

Thenar Space Infection (*Fig* 1429) is bounded on the *palmar aspect* by palmar fascia, on the *dorsal aspect* by the adductor pollicis (transverse head), and on the *ulnar aspect* by the fibrous septum referred to above. The space can become infected by bursting of a suppurating tendon-sheath of the index finger or of the thumb, or from a penetrating wound. Ballooning of the thenar eminence (*Fig* 1430) causing abduction of the thumb

Fig 1430.—Empyema of the thenar space. Ballooning of the thenar eminence.

Fig 1431.—Incision for draining an empyema of the thenar eminence.

is characteristic of this lesion. Again, infection of this space has, like the foregoing, become somewhat of a rarity, owing to the frequent successful treatment of infected tenosynovitis by antibiotic therapy.

Operation.—An incision through the skin and superficial fascia, parallel with and ½ in. (1.32 cm.) below the metacarpophalangeal flexion crease, and keeping towards the web (*Fig* 1431), opens the abscess, which is usually walled off from the muscles of the thenar

INFECTION OF THE DORSAL SPACE

The frequency with which pitting oedema accompanies pus in the palmar aspect of the hand has resulted in neglect of an appreciation of the dorsal fascial spaces as a site of infection, and a reluctance to incise the dorsum of the hand. The most frequent causes of dorsal space infection are a boil of the overlying skin, or a penetrating wound. Infection of the dorsal subcutaneous space of the hand is fairly common, as also is the corresponding space in the proximal segment of the digits (*Fig* 1432) that of the dorsal subaponeurotic

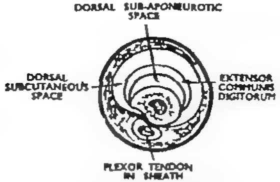


Fig 1432.—Cross-section of finger showing the relationship of the dorsal subcutaneous and dorsal subaponeurotic spaces. These spaces are continued downwards on to the back of the hand, bearing the same relationship to the extensor tendon.

space is rare If swelling of the dorsum accompanied by tenderness, induration, and perhaps redness persists for more than 48 hours, fluctuation should not be awaited.

Operation.—*An incision about ½ in. (1·25 cm.) long, which in this instance can be vertical is made over the point of greatest tenderness.*

INFECTED TENOSYNOVITIS

The most frequent cause of infected tenosynovitis is puncture of a volar flexion crease of a digit In these situations, not only does the tendon-sheath lie just beneath the very thin skin that covers the crease but opposite the joints the sheath is devoid of a fibrous coat—the so-called pulleys (*Fig* 1433). Of these vulnerable creases, it is the distal one that is punctured most often. Exceptionally the sheath is infected by extension from the terminal pulp space In the past this occurred with some frequency from the scalpel transgressing the hallowed ground of the septum that closes the proximal end of the space (*see Fig* 1418) Because of their continuity with the ulnar and radial bursæ the most dangerous sheaths to become infected are those of the little finger and the thumb. Nevertheless, it should be appreciated more widely that anatomical research has proved that *the sheath of either* the index, middle, or ring finger or combinations of these communicates with the ulnar bursa in 11 per cent of cases (E. W Scheldrup). The typical arrangement of the sheaths is shown in *Fig* 1434.

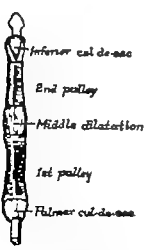


Fig 1433.—The digital sheath, showing the particularly vulnerable areas where the fibrous layer is lacking (*After M Iselin*)

The relationship of the flexor tendon-sheaths to the lumbrical muscles is of surgical importance

The lumbrical muscles arise from the tendons of flexor digitorum profundus, the outer two by one head, the inner two by two heads. Their tendons pass around the *radial* side of the corresponding digit to reach the expansions of the tendons of the extensor digitorum, into which they are inserted.

The lumbrical canals act as conducting channels for pus to travel from an infected tendon-sheath to the middle palmar space The weakest part of a tendon-sheath is its proximal end. When a sheath becomes over-distended it is here that it bursts. By referring to *Fig* 1433 it will be appreciated that pus from a ruptured tendon-sheath enters the corresponding lumbrical canal.

incision (*Fig* 1436) is made over the proximal cul-de-sac which is opened. Through this incision a ureteric catheter is introduced into the sheath, which is irrigated with normal saline solution. 100,000 units of penicillin in 5 per cent saline solution is then injected.

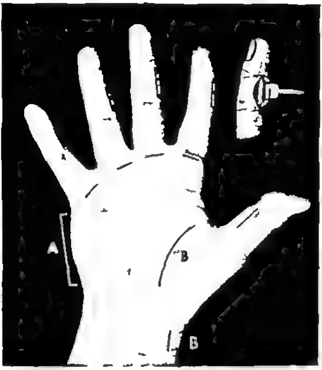


Fig 1436.—Incisions for opening infected tendon-sheaths. A, Additional incision when the ulnar bursa is implicated; B B, Additional incision when the radial bursa is implicated.

Results—Seventy per cent excellent, 15 per cent fair and 15 per cent poor.

Localized Infected Tenosynovitis is relatively common owing to the early antibiotic treatment enabling Nature to limit the infection to a portion of the sheath by adhesions. In this instance the infecting organism is frequently a staphylococcus. Swelling and tenderness are confined mainly to one segment of the digit, rendering the differential diagnosis from infection of a mid or proximal volar space very difficult. In these circumstances, after a period of conservative treatment without marked improvement, it is expedient to open the pulp space through a lateral incision (*Fig* 1437). *If the pulp is free from pus* the fibrous pulley of the sheath is divided. The theca can then be seen clearly. Some of the fluid within it is aspirated and sent for bacteriological examination. Unless the fluid is perfectly clear the theca is incised.

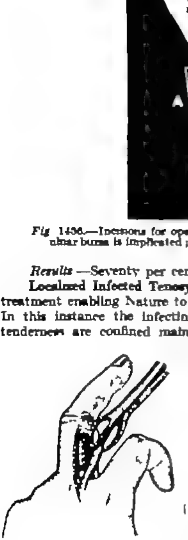


Fig. 1437.—Lateral incision for exposing the flexor tendon-sheath in the proximal segment of the middle finger. (*After M. Iselin.*)

INFECTION OF THE ULNAR BURSA

Infection of the ulnar bursa is characterized by:—

1. Œdema of the whole hand, especially the dorsum, due to lymphatic spread.
2. Moderate swelling of the palm.
3. Sometimes a fullness immediately above the flexor retinaculum.
4. The flexed fingers resist extension, the maximum difficulty being experienced in the little and the least in the index, finger.

5. Especially valuable is Kanavel's sign (*Fig* 1438) The area of greatest tenderness is over that part of the ulnar bursa lying between the transverse palmar creases.

It should be noted that the ulnar and radial bursae intercommunicate in 80 per cent of cases, and often when an untreated infection of one has persisted for more than 48 hours, the other becomes involved as well. As has been noted (p 1016) in 11 per cent of cases the tendon-sheaths of digits other than that of the little finger communicate with the ulnar bursa This little-known fact is of great surgical importance.

Operation.—In addition to opening the involved tendon-sheath along the lateral aspect of the middle segment of the finger the following method of draining the ulnar bursa is recommended

Fig. 1438.—Kanavel's sign for ulnar bursitis—point of maximum tenderness in the site marked with a cross.

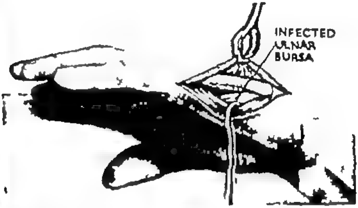


Fig 1439 —The greater part of the opponens has been divided after retraction of the abductor muscle Beneath the deep fascia lies the ulnar bursa.

Henry's Approach.—After the skin and deep fascia have been incised over the anterolateral aspect of the fifth metacarpal (*see Fig* 1436) the abductor and flexor digiti minimi are separated from the bone and retracted forwards, displaying the opponens, which is divided close to its attachment to the bone. The fascia deep to this muscle is incised and the distended bursa bulges into the wound (*Fig* 1439) If the bursa has been emptied via the infected tendon-sheath, a curved probe passed from the original incision will enable the wall of the bursa to be identified and incised.

INFECTION OF THE RADIAL BURSA

Infection of the radial bursa is characterized by —

1 Flexion of the distal phalanx of the thumb. The thumb only is flexed—it is completely rigid and inextensible. The other digits can be extended fully

2. Tenderness over the sheath of the flexor pollicis longus.

3. Sometimes swelling just above the flexor retinaculum.

Treatment.—While in early cases antibiotic therapy should be given a trial the perils of leaving this sheath undecompressed include extension to the ulnar bursa and, because the sheath is particularly unyielding necrosis of the tendon of the flexor pollicis longus.

Operation.—The sheath can be decompressed adequately by the incisions shown in Fig 1436 being vigilant not to extend the proximal incision farther than ¾ in. (1 8 cm.) distal to the flexor retinaculum, lest the branch of the median nerve to the muscles of the thenar eminence be injured. Should pus well up when pressure is exerted over the wrist a ureteric catheter is passed down the sheath, and a third incision is made on to the catheter above the retinaculum In this way the proximal cul-de-sac can be opened safely and drained through a small incision. Irrigations with saline solution followed by penicillin solution are carried out as directed on p 1018.

LOCAL COMPLICATIONS OF INFECTED TENOSYNOVITIS

Sloughing of the Tendon.—If at the time of the operation a few fibres only are seen to be necrotic, these should be excised. When most or all of the circumference of the

tendon is yellow and has lost its pristine glistening appearance, the incision must be extended downwards. If the length involved is limited, the first glistening (viable) proximal portion of the tendon is grasped firmly in a hæmostat the tendon is transected distal to this, and again just above its insertion. A fundamental step of the operation is to transfix the tendon below the hæmostat with a needle carrying an unabsorbable suture and by so doing to anchor the tendon stump to its sheath and surrounding tissues. On no account should the severed proximal end of the tendon be allowed to retract and possibly carry infection into the palm. The hæmostat is then removed and the crushed portion trimmed with scissors.

Another contingency is when a sloughing tendon is a cause of continued suppuration after an operation for infected tenosynovitis. The condition can be diagnosed with assurance if the radiograph is negative and involvement of another space has been eliminated. Having confirmed the diagnosis by re-opening the wound and extending it as necessary if as is usually the case a greater part of the exposed tendon is non-viable amputation of the affected finger through the metacarpophalangeal joint is the best course Again a glistening (viable) portion of the tendon is grasped in a hæmostat before it is severed distal to the hæmostat. After the finger has been disarticulated the divided proximal end of the flexor tendon is transfixed and stitched to the cut end of the extensor tendon or to surrounding soft parts. In the case of the thumb the non-viable tendon should be excised with the same precautions regarding its retraction but the digit is not sacrificed

Fig 1440.—Radiograph of a case of suppurati e tenosynovitis of the index finger complicated by necrosis f the middle phalanx and suppurative arthritis of the terminal interphalangeal joint

Osteomyelitis is a rare complication that attacks the middle more often than the proximal phalanx (*Fig* 1440). If after the tendon-sheath has been drained pain, worse at night, persists, and there is no undue tenderness in other situations in the hand, the most probable cause is that osteomyelitis is proceeding in one of the phalanges. Careful palpation over the dorsal aspect is the best guide in the early stages. After the fifth day there will probably be sufficient bone destruction to afford radiological evidence. The presence of osteomyelitis is a clear indication for continuing antibiotic therapy As soon as a sequestrum has formed it must be removed through a dorsal incision.

Infected Arthritis can complicate infected tenosynovitis and either the distal or the proximal interphalangeal joint may be implicated by a deep prick which passes through the tendon-sheath and the tendon. The symptoms are similar to those of osteomyelitis, but the tenderness is most acute over the joint. If suspected, the contents of the joint should be aspirated (*see also* p. 903) and the pus sent for culture and sensitivity test For treatment, *see* p. 910.

Stiff Finger.—When the patient is left with a stiff finger provided the finger has been allowed to ankylose in a position of function, it is likely to prove a useful member in many walks of life. When the digit only gets in the way it is better amputated (*see* p 1000). A stiff ring finger above all other fingers, holds back the other fingers from flexion and extension. This fact should be taken into consideration when debating whether or not to amputate (S. Bunnell).

Paralysis of the Median Nerve.—When signs of a median-nerve palsy develop in a case of infection of the hand early decompression of the carpal tunnel by severing the flexor retinaculum is recommended by H Bailey and J F B Carter who found the median nerve obviously compressed in two such cases. In these circumstances palsy of the median nerve is due to compression by inflammatory exudate in the radial or ulnar bursa or (more frequently) in both bursæ

INVOLVEMENT OF THE FOREARM FROM THE HAND

When a radial or ulnar bursa, distended with pus, bursts, or an infected middle palmar space remain undrained pus travels up the forearm between the flexor digitorum profundu ventrally and the pronator quadratus and the interosseous membrane dorsally It is here in the space of Parona, that a quantity of pus can collect without giving rise to much swelling There is, however brawny induration above the wri t and great

tenderness on deep pressure unless the original lesion has been incised and continues to discharge pus. Therefore in cases of infection of the radial or ulnar bursa, if pus can be expressed by pressure over the wrist at the time of operation or subsequently it is essential that the forearm be drained in the following manner

Operation.—Commencing ¾ in. (1.8 cm.) above the styloid process of the ulna, an incision is made along the easily palpable anteromedial surface of the ulna the incision which should be nearly 4 in. (10 cm.) long is deepened through the fascia. The tendon of the flexor carpi ulnaris is identified, and in the upper part of the wound fibres of the muscle are detached from the bone allowing this muscle to be retracted. At this stage if the ulnar bursa is distended with pus, its cul-de-sac can be seen (*Fig.* 1441). In any event the key to the situation is the pronator quadratus, and its fibrotendinous fibres, running in a transverse direction, must be displayed. With the pulp applied to the anterior surface of the pronator quadratus, the finger is inserted beneath the flexor tendons. Frequently pus escapes as soon as the space is entered because the ulnar bursa has burst already. If pus does not flow the bursa is opened widely. When there is pus in the space of Parona a hæmostat is passed over the anterior surface of the pronator quadratus until its beak appears beneath the skin on the contralateral side. In this way through-and-through drainage (*Fig.* 1442) is established and maintained by a strip of corrugated rubber.

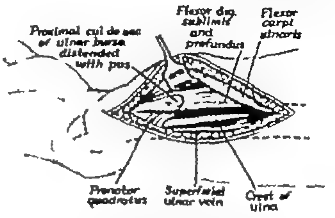


Fig. 1441.—Exposure of the cul-de-sac of the ulnar bursa in the forearm, which is also the method of draining the space of Parona with precision. (*After L.-H. Farabeuf.*)

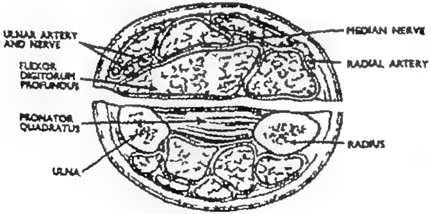


Fig. 1442.—Through-and through drainage of the space of Parona.

SYMBIOTIC INFECTION

The combination of micro-aerophilic non-hæmolytic streptococcus and hæmolytic *Staph. aureus* produces a destructive lesion of the skin and subcutaneous tissues. The gross appearance is quite characteristic there is an outer zone of erythema, an intermediate dark purple zone, and an inner zone of gangrenous skin. The centre of the lesion becomes a granulating ulcer which in turn may become bright red and clean. The lesion continues to spread until the patient dies or the infection is brought under control. The usual antibiotics are of little avail, but F. L. Meleney has found that bacitracin is of considerable value. The usual treatment is wide excision and antibiotic therapy that is inimical to the organism present as demonstrated by sensitivity tests. Occasionally activated zinc peroxide is beneficial.

INFECTIONS OF THE FOOT

The subject of infections of the foot does not lack importance. The world over these infections are common. Infections of the sole are particularly frequent among coolies and those who work barefooted, while the other infections about to be described occur for the most part in those who go about their business shod.

That antibiotic therapy, and when possible antibiotic therapy that conforms with the bacteriological sensitivity tests of the organism or organisms isolated from the pus, will be employed in all cases, and that an incision into an œdematous—as opposed to an indurated—area will not be made, is assumed, for these cardinal injunctions have been emphasized so often in modern writings concerned with the sister subject—infections of the hand.

Infected Blister is one of the most common infections of the foot. When the temperature is normal and the contents of the blister appear doubtfully purulent, after cleansing the whole foot with soap and water, or preferably a detergent, applied with sterile gauze or cotton wool, the blister can be aspirated. If the fluid is opalescent the patient should be given penicillin and the fluid should be sent for bacteriological examination. *When the blister is frankly purulent it should be incised.*

Paronychia, particularly of the great toe, is also common. It often occurs as a complication of an ingrowing toe-nail. An abrasion of the eponychium with contaminated scissors is also a frequent cause. The clinical features and the treatment do not differ from that of a paronychia of a finger or a thumb, with the exception that when an ingrowing toe-nail is present it is necessary to remove the corner of the nail that projects into the tissues. This is carried out with nail clippers which cut the nail close to the lateral margin for about ¼ in. (6 mm.). The freed portion of nail is then rolled from beneath the eponychium and removed. In all cases washing (*see above*) is carried out each time the wound is dressed.

Infected Adventitious Bursa associated with a Corn.—The small bursa that forms between a corn and the projection of bone that causes the corn usually becomes infected as a result of improper chiropody. There are signs of inflammation around the corn. Even the slightest pressure on the corn causes excruciating pain. The prelude to treatment consists in thorough washings of the foot as described previously. Drainage is then accomplished by trimming the corn with a sterile scalpel. The corn is pared until pus exudes; usually this can be undertaken without an anæsthetic. The remainder of the treatment follows general principles, but bed rest and elevation of the foot must be insisted upon until the inflammation has subsided.

Infected Bursa over a Hallux Valgus.—The infection usually occurs through the skin. Frequently the overdistended bursa ruptures, to form a sinus; secondary infection then takes place. In a few instances the skin is calloused over the bursal area, and improper trimming results in infection. In cases not associated with a sinus the possibility of acute gout of the metacarpophalangeal joint must not be overlooked. One should search for tophi, and when possible have a blood uric-acid determination undertaken. If the diagnosis of gout is favoured, trial therapy with colchicum is valuable, but penicillin should be given as well until the diagnosis of gout is confirmed.

The treatment of this infected bursa follows general principles. It is highly important that removal of the bursa, together with the underlying cause, e.g. a hallux valgus, should not be carried out until several months have elapsed after all signs of inflammation have disappeared. Even then, the operation should be performed under antibiotic cover.

Terminal Pulp-space Infection is very uncommon as compared with this clinical entity in a finger or a thumb. Its diagnosis and treatment do not differ from that of its counterpart. When it occurs in the foot, usually it is the great toe that is affected.

Suppurative Tenosynovitis.—The flexor tendon-sheaths of the toes are short. Each extends only the length of the toe and has no connexion with any of the synovial sheaths of the tendons around the ankle—facts which tend to reduce the incidence of complications of suppurative tenosynovitis of a toe when compared with a corresponding lesion of a finger or a thumb. Furthermore, should a partially or completely stiff digit result, the disability it occasions is infinitesimal when compared with that of a stiff finger or thumb.

Suppurative tenosynovitis of a toe is rare. The physical signs it produces are comparable in every way to infection of a tendon-sheath of a finger that does not

communicate with the ulnar bursa When the symptoms and signs persist in spite of 24 hours of rest elevation, and antibiotic therapy there should be no hesitation in opening the flexor tendon-sheath throughout its length

INFECTION OF THE SUPERFICIAL FASCIAL SPACES OF THE SOLE

Like the palm of the hand, the superficial lymphatics of the sole converge on the dorsum by the shortest route i.e., through the webs. Thus when pus lies either super-ficial or deep in the sole inflammatory œdema is most evident on the dorsum. In most instances this œdema also involves the ankle less often it extends to the lower part of the leg Pitting-on-pressure distinguishes œdema of the dorsum of the foot from the indurated brawny swelling that is present when pus lies in the dorsal subcutaneous space

INFECTION OF THE WEB SPACES

The web spaces—four in number—extend on to the dorsal as well as the plantar aspect of the foot (*Fig* 1443), the space between the great toe and the second toe being

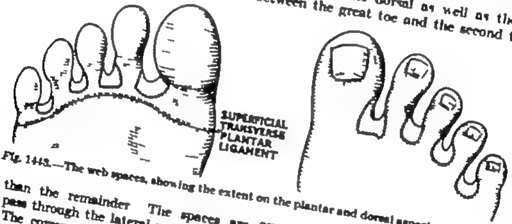


Fig. 1443.—The web spaces, showing the extent on the plantar and dorsal aspects of the foot.

larger than the remainder The spaces are filled with fat. The digital vessels and nerves pass through the lateral parts of these spaces. Each space communicates with —

1. The corresponding interdigital subcutaneous space beneath the superficial transverse plantar ligament.
2. The subcutaneous space of the related digits.
3. The dorsal subcutaneous space

The diminutive lumbrical tendon passes through the proximal part of the space and, as in the hand, it can serve as a conductor of pus, in this instance to bring the web space into communication with the corresponding interdigital subcutaneous space.

Diagnosis.—There is localized tenderness over the dorsal and the plantar aspect of the web

Drainage[1] is effected by making an incision through the plantar aspect of the space care being taken not to injure the superficial transverse plantar ligament. When necessary a counter incision is made on the dorsum, and thereby through-and through drainage is effected. A piece of corrugated rubber is always left in place for at least 24 hours.

The Interdigital Subcutaneous Spaces.—There are four interdigital subcutaneous spaces which lie between the five digital slips of the central aponeurosis (*Fig* 1444) the most medial space is larger than the others. Each of these spaces is roughly pyramidal in shape and is filled with fat. Within each space lies a digital nerve and in the distal half of each space the digital vessels gain entrance by penetrating the floor of the space Proximally the interdigital subcutaneous spaces communicate with the most

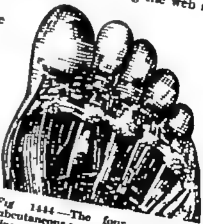


Fig 1444—The four interdigital subcutaneous spaces between the five slips of the central aponeurosis

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[1] In the diabetic patient the treatment of web-space infection, which is not uncommon, and also suppurative tenosynovitis by orthodox drainage is so disappointing that these infections should be regarded as an urgent indication for amputation of the relevant toe the wound being left open.

(*Fig* 1447), gives a direct approach, free drainage and avoids leaving a scar on the pressure-bearing area of the sole. Keeping close to the bone the incision is deepened until the intermuscular septum is reached (*Fig* 1448); this is incised at a level near the sole, and Compartment I is entered. If pus is not present in Space I the incision must be extended distally to the level of the base of the first metatarsal. The incision in the aponeurosis is extended and the flexor digitorum brevis is exposed. Its medial border is identified, and a hæmostat is passed above the muscle and directed dorsally and towards the heel. Any one of the three deeper spaces can be explored through this incision. At the level where the pus is struck the hæmostat is directed towards the neck of the fourth metatarsal well opened and a drainage tube inserted.

Fig 1447.—Incision for draining the central and medial plantar spaces.

In the rather unusual event of plantar drainage proving insufficient a counter incision is made on the dorsum of the foot in the fourth intermetatarsal space. The skin and subcutaneous tissues are opened, and the extensor tendon slips to the toes are identified. They are retracted, the aponeurosis is incised and a hæmostat is thrust into Compartment III or IV of the central plantar space whichever is the seat of the abscess. The jaws of the hæmostat are opened, and the space is drained through the dorsal incision. The dorsal approach should be used only if drainage through the medial incision described proves ineffectual after several days.

After-treatment.—Rest on a back splint, with the leg raised on pillows or preferably swung in a Bloxham's cradle is maintained for two or three days, or until the pulse and temperature are normal. The patient should then be taken to the operating theatre

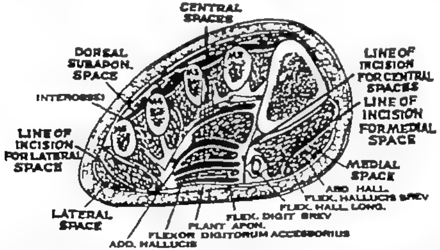

Fig 1448.—Transverse section through the middle of the metatarsals, showing fascial spaces. The lines for opening the lateral, medial, and central spaces are shown. Not especially that each of the four compartments of the central space can be opened by the same incision if the fascial septum is incised. (*After M. Grodinsky.*)

and the wound or wounds are packed lightly with petroleum-jelly gauze and a plaster cast applied. After the patient has been returned to bed the limb is again elevated. Fixation in a plaster is most important otherwise contractures are liable to occur resulting in a considerable deformity of the foot that is most difficult or even impossible to correct. After ten days or a fortnight unless there is ... on for doing so before the plaster cast is removed and renewed. The patient ... ulatory during this period, but the cast should be re... the wound ... After removal of the plaster œdematous swelling ... ur and is ... for although it is not usually associated with ... be increased ... foot makes it impossible to wear an ordinary sh... be pres... ... fication of

an Unna's paste bandage to the foot and leg immediately after removal of the cast. The bandage must extend from the base of the toes to the tuberosity of the tibia, and should be kept on for six weeks or longer if the tendency to swell persists. When the bandage becomes dirty it is changed. In due course an orthopaedic shoe will be required in most cases.

Drainage of the Lateral Plantar Space.—To evacuate pus from the lateral space the incision shown in *Fig* 1449 is employed. The incision passes through the skin and subcutaneous tissue and the space is opened widely by incising the deep fascia. Corrugated rubber drainage is provided.

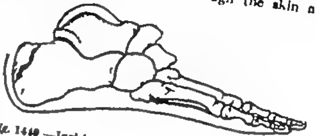

Fig. 1449.—Incision for draining the lateral plantar space

Drainage of the Medial Plantar Space.—The incision is almost the same as that advised for the central plantar space (*see Fig* 1447) but it should be made a little more towards the plantar aspect of the foot and over the site of maximum tenderness. It should be the rule always to evacuate pus from the plantar aspect of the foot through an incision over either the medial or the lateral border of the foot. Such incisions not only provide adequate drainage but ensure that the subsequent scar is well away from the weight-bearing area.

INFECTIONS OF THE DORSUM OF THE FOOT

The Dorsal Subcutaneous Space is usually infected from an extension of infection from a subcutaneous interdigital space or from a web space. Occasionally localization of infection occurs in the space when infection spreads from the sole to the dorsum by way of lymphatics. Such localization is always distal to the dorsal venous arch. The incision should be placed parallel to the vessels or nerves, in order to avoid them.

The Dorsal Subaponeurotic Space.—While this space can be infected from direct puncture, it can also be involved from an extension of infection from plantar Space IV. When infection of this space is suspected aspiration should be attempted and the diagnosis confirmed before the incision is made. A longitudinal incision is then made alongside the needle. The cavity is drained with corrugated rubber for 24 hours.

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CHAPTER LXXXVII

REMOVAL OF BROKEN NEEDLES

ALTHOUGH the removal of a broken needle is often a simple matter it can be fraught with considerable (and unexpected) difficulties. Chief of these is that at open operation, even with radiographs before one it is not unusual to be unable to locate the needle for some time for when it is embedded in even a small amount of muscle often the needle can neither be seen nor felt with a probe or the finger. There are occasions when these difficulties prove insuperable. Consequently it is highly desirable to dwell upon the problem beforehand and consider —

1 Whether exploration is really essential i.e. what harm might accrue from leaving the fragment in situ?

2 *How long should the search continue if the needle proves difficult to find?*

Seeing that the operation frequently lasts longer than is anticipated at any rate in children in poor risk subjects, and when the seeking of a small fragment seems of doubtful necessity if a general anæsthetic is to be employed a predetermined time limit for the search should be agreed upon with the anæsthetist before the operation is commenced.

A 17 year-old seamstress broke a needle in her thenar eminence. Gas anæsthesia was employed, and as the needle could not be found, the search continued for an hour. Cardiac arrest then ensued, and the patient died on the operating table.

Unless the (hollow) needle was sterilized before introduction, a prophylactic injection of penicillin is given. If apparent with the naked eye or a magnifying glass, the point

Fig 1430.—Radiographs showing broken hollow needle in the buttocks.

of entry should be ringed round, using preferably an indelible pencil, or ink. When the needle lies near a joint the limb should be immobilized in the position it will occupy on the operating table.

Preparation of the Skin. The surrounding skin should be shaved if necessary washed, wiped with alcohol and covered with a sterile towel *before the X-ray examination.* Precise instructions must be given to the nurse-in-charge that if the point of entry has been ringed round she must provide herself with an indelible pencil (or pen and ink) and should the ring become faint during the ablutions she must re-mark *the skin before this* important guide becomes lost.

Radiological Localization. It is hardly ever justifiable to undertake deep exploration for a broken needle without a preliminary X-ray examination. Radiographs, to be of value must be in two planes (*Fig.* 1430). C. W. Cutler's method of placing two wires over the site of entry (*Fig.* 1431) and then taking radiographs in planes at right angles is an extremely practical aid for the recognition of the site of a broken needle especially in the hand or foot. When the needle lies embedded in a large muscular mass, the radiographs should be obtained by movement of the X-ray tube and not by movement of the

patient the reason being that alteration of pressure on the soft parts may alter the apparent position of the foreign body considerably (Hodgson and Ramage). When possible the part (especially the hand or foot) should be placed on the X ray table in the same position as it will subsequently be placed on the operating table

Fig 1431.—Crossed wires are kept in place with adhesive plaster over the point of entrance Antero-posterior and lateral radiographs are then taken.

Attempted removal of a needle in the radiological department under the fluorescent screen is seldom satisfactory Apart from the real risk to the surgeon's hands, asepsis is endangered, and groping about in the dark is highly unsatisfactory

Limited fluoroscopy for the sole purpose of determining the situation of the foreign body is however of signal service and whenever possible one or more of the following methods should be invoked in addition to taking the usual radiographs —

1 The site of the lost fragment is marked on the skin the best method being to scratch the skin with a sterile needle or a fine pointed scalpel and then rub in Indian ink (P Cave).

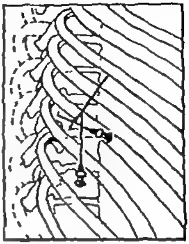

Fig 1432.—Drawing of a radiograph showing slender hollow needles (preferably fine lumbar puncture needles) inserted through the soft tissues of the chest wall, so that they cross in approximately the same position as one end of the broken needle (*After Gardner and Durham*)

2. After raising a weal of local anæsthetic and introducing a fine hollow needle of suitable length in a plane horizontal to the table lights are switched out and the X rays are switched on Under the fluorescent screen the hollow needle is advanced until the point touches, and if possible moves the foreign body ½ ml. of methylene blue is then injected, so as to stain the surrounding tissues. This is a real boon in indicating the approximate site of the needle at open operation.

3. In addition to the above after injecting local anæsthetic a second hollow needle is inserted directly over the foreign body at a right angle to the horizontal plane until its point also touches the foreign body If this method is used, both the hollow needles (*Fig* 1432) are left in situ, and the patient is transferred (with great care not to move these needles) to the operating table After the patient is anæsthetized an incision is made between the two localizing needles.

Berman's Metal-locator.—For locating needles and other small metallic foreign bodies, Lambert Rogers has found Berman's metal locator (*Fig* 1433) invaluable

Anæsthesia.—Never attempt to remove a needle under short gas or intravenous thiopentone anæsthesia. It may require much patience to find the object and the operator must not be hurried Since the direct injection of local analgesic solution is prone to confuse the anatomy of the part, a regional nerve block or full general anæsthesia must always be employed.

Broken Needle in the Hand.—In this common site for a broken needle Cutler's aid to localization proves eminently suitable (*see Fig* 1431).

When the patient has been anæsthetized, apply a pneumatic tourniquet and place the hand upon a side table and sit down to work. Make the skin incision obliquely over the line of the needle (*Fig* 1434) then commence the search. Usually a probe is passed into the wound and moved about A muffled ping is heard. Many times have I seen a look of satisfaction on the operator's face turn to disappointment on finding that it is some tendinous structure which the probe has struck. The following is suggested as a better mode of procedure: make an incision large enough to allow the insertion of the little finger Touch-corpuscles will detect foreign bodies when the probe will not. After feeling around systematically with a negative result mobilize a tendon or muscle by blunt dissection, and holding this aside introduce the finger once more and feel again. If this

is not successful enlarge the incision and dissect carefully. With a reasonable knowledge of anatomy nothing of importance will be damaged, and the needle must surely be found.

Hollow Needle broken off in the Thorax.—

I was asked to see a young man whose doctor gave the following history. The patient had had pneumonia, and empyema was suspected. A hollow needle was inserted, and while the syringe was being adjusted the patient gave a violent cough. The needle broke and about 3 in.

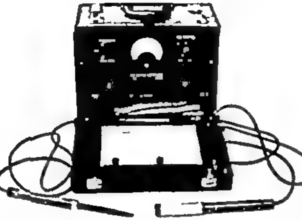

Fig. 1452.—Berman metal-locator. (*Professor Lambert Rogers.*) (*The Lancet.*)

(7.5 cm.) remained in the chest. Radiographs showed the needle in the lower part of the chest above the diaphragm. Choosing the point of puncture as a guide, two adjacent ribs were resected under local anæsthesia. On opening the pleura the needle could be seen penetrating the diaphragm and moving to and fro with its excursions. The needle was seized and removed without difficulty. The lung appeared to be in a state of red hepatization, and did not collapse very much when the pleura was opened. The wound was therefore closed without drainage. A hollow needle was then inserted into the pleural cavity just beneath the incision and as much air as possible aspirated. The patient made an uninterrupted recovery.

Fig. 1453.—Incision for removal of a needle in the hand.

Needle in a Joint.—Arthrotomy must be performed in order to remove the needle. The best method of opening each joint is described on pp. 907–910.

Lumbar Puncture Needle broken in the Spine.—The first step is to take a radiograph in two planes, to ascertain the exact location of the needle, as the puncture mark in the skin is often misleading and should never be relied upon. The second important step is to make a longitudinal midline incision such as is used in laminectomy. It may be sufficient to dissect muscles off the spinous processes on one side only. At other times it is necessary to bare the laminæ on either side and to remove the relevant spinous processes; possibly the broken shaft of the needle will be located in the interspinous ligament after the spinous processes have been removed.

L. H. Landry's Case.

The patient was a man of 31. The needle had broken off during lumbar puncture the day previously. The patient was complaining of severe pain radiating down the thighs. An incision was made over the third, fourth, and fifth lumbar vertebræ and the laminæ were exposed as for laminectomy. It was not until the spinous processes had been removed that the needle was found between the third and fourth vertebræ. Its removal was followed by a flow of cerebrospinal fluid.

Only in most exceptional circumstances is it necessary to remove the laminæ of one or more vertebræ.

Broken Needle in the Tonsillar Fossa is evidently not the almost unheard-of happening that might be supposed. Of 30 otorhinolaryngologists present at a meeting, 14 had had experience of the accident. More than half the broken needles were hollow needles used for injecting local anæsthetic; the remainder were sewing needles of one kind or another. Several of the hollow needles were removed by an electromagnet; most of the sewing needles were never recovered. Only one complication was reported, and that resulted in the death of the patient due to over long general anæsthesia during attempted removal. There was mention of one needle that migrated to several places in the neck without symptoms. However, complications occurred in 12 per cent of cases compiled by J. A. Weiss. They included fracture of the hyoid bone during attempted removal, persistent glossopharyngeal neuralgia, infection of the pterygomaxillary space, and pain on swallowing.

As a result of another inquiry, 67 otorhinolaryngologists replied to a questionnaire that they had experienced this accident. Consequently it must be assumed that but few harassed operators record their tribulation.

Utilization of one hollow needle as a marker has been recommended, but there is a danger of piercing the carotid artery, which is difficult to avoid. One thing is certain —that this is a very difficult region from which to retrieve a broken needle. If an electromagnetic installation can be employed, arrangements to take advantage of this aid should be made. Not more than half an hour should be allowed for the search if an intra-oral approach is used, as it should be in the first instance. If this is of no avail, it would appear that a second attempt via an external approach is more likely to succeed. Having regard to the possible legal implications, an outstanding difficulty is explaining to the patient and his relatives why an external operation is necessary. Probably the best course is to explain the situation to a responsible relative, to see the patient at three-monthly intervals, and to operate only if there are symptoms or if serial radiographs show that the needle is migrating.

Lost Radium Needle.—For obvious reasons a lost radium needle must be removed with as little delay as possible. On account of the comparatively large diameter of the needle the operation seldom, if ever, presents difficulty unless the anatomical site of the implantation is deep.

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CHAPTER LXXXIII

THE EYE AND THE ORBIT

By F. A. Williamson-Noble, B.A., M.B., B.Ch.(Camb.)
F.R.C.S. Eng. (with Ophthalmology)

(In former editions this chapter was written by the late Eugene Wolff. A considerable amount of his text has been retained.)

FOREIGN BODIES IN THE EYE

1. In the Conjunctival Sac.—*One of the most frequent emergencies that a surgeon may have to deal with is a foreign body in the conjunctival sac.* If it has lodged under cover of the lower lid, it is readily removed by the patient or his friends. The patient looks up, the lower eyelid is pulled down, and the foreign body is usually easily removed with the finger, the corner of a handkerchief, or preferably with some cotton-wool moistened in boracic lotion and wound around the pointed end of a match-stick.

A foreign body underneath the upper eyelid is quite a different matter, for while in expert hands it is usually not difficult to evert the upper eyelid, it may prove impossible to someone not used to the procedure, especially if the patient is unruly, as is not infrequently the case. It is therefore strongly advised that the procedure of everting the upper eyelid should be practised at every opportunity.

Underneath the upper eyelid the foreign body usually lies in the subtarsal groove some 2 to 3 mm. from the lid margin, and about half way along its length where the tarsal plate is most concave. In this position, owing to the movement of the lid, it is continually rubbing on the cornea, which causes pain and watering of the eyes. A drop of ½ per cent pantocaine into the conjunctival sac will help greatly by taking the pain away and giving the patient confidence, which makes everting the upper eyelid a much easier matter. This is done as follows:—

The surgeon stands in front of the patient who is told to look down; this is an essential part of the manœuvre and is made easier for the patient, if he is told to look at his feet with the unaffected eye, not turning his head down.

The surgeon rests the ulnar border of his index finger (right for the left eye and left for the right) along the upper lid and the thumb on the lower lid. The upper lid is then drawn gently away from the nose so that the lower lid can be slid under it by a slight upward movement of the thumb, continuation of which results in eversion of the upper lid, provided the patient continues to look downwards (*Fig.* 1433).

It will thus be seen that eversion of the upper lid is essentially a rotation of the tarsal plate around a transverse axis, so that its upper border passes between the lid margin and the globe. The removal of the foreign body once the lid is everted is usually quite easy and can be done with the finger or moist cotton-wool wound around a match-stick.

Double Eversion of the Upper Eyelid.—In order to bring into view the upper fornix where foreign bodies may also lodge, the upper eyelid is first everted in the usual way. While the patient looks down and the lid is held everted with one hand, the thumb of the other presses the globe into the socket; the fornix and retrotarsal fold will now roll into view. This procedure is known as double eversion of the upper eyelid. In some cases this manœuvre fails. In these the upper edge of the everted tarsal plate should be gripped with the forceps, held horizontally and gently turned upwards. Previous instillation of two more drops of ½ per cent pantocaine is advisable.

2. In the Cornea.—Light objects, such as wings of insects or husks of grain, may simply adhere to the corneal epithelium. Heavier objects coming with more force, such

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Subtarsal groove: The groove in the conjunctival surface of the upper lid near its margin.
Fornix: The fold of conjunctiva uniting that covering the inner surface of the lids with that covering the eyeball.

as particles of steel or emery penetrate to varying depths. All foreign bodies in the cornea result in pain photophobia with its accompanying narrowing of the palpebral fissure, and diminution in the size of the pupil *These signs in fact should make one look again for a foreign body or abrasion even when a first examination has been negative* In many cases the foreign body is better seen when the pupil is dilated with homatropine In any case when *trying to find the foreign body the surgeon must ask the patient to* look in various directions. If difficulty is experienced then the position of the foreign body may be shown up by a drop of 2 per cent fluorescein (*see* p. 1041).

Removal of the Foreign Body.—The eye is anæsthetized with 4 per cent cocaine because of its softening effect on the corneal epithelium which allows the foreign body to be removed more easily than if pantocaine is used. If the foreign body is merely adherent it may be removed with a piece of white blotting paper cut to a point or better with some cotton-wool moistened in boracic lotion and wound tightly around the end of a thin glass rod. Even if the foreign body is embedded it may often be removed by the above technique provided the surgeon will wait a few moments after cocainizing for the epithelium to soften.

Fig. 1458.—Eversion of the upper eyelid. The patient looks down, the upper lid is drawn *upwards as far as possible by the surgeon s thumb.*

Should this fail the foreign body has to be removed with an instrument Various forms of needle have been employed but a fine hypodermic needle attached to a 1 ml syringe is as good as anything, since its bevelled point can be slid under the foreign body so as to lever it out, with as little damage to the corneal substance as possible.

The patient, with the eye cocainized, lies on a couch, and the surgeon standing behind him, using preferably a binocular loupe separates the lid margins with the forefinger and thumb of the left hand. The pulp of the finger is placed on the lid margins and not on the skin of the lids in this way the globe can be steadied at the same time. Particles of steel and emery often leave a ring of rust Experts will remove this ring but attempts by inexpert hands to remove it will often result in more damage than the rust will cause.

After the removal of the foreign body the eye is covered with a pad and bandage, and in fact treated as an ulcer Atropine is indicated where there is much redness, or where the wound that is left is deep or wide. In most cases homatropine and cocaine will suffice. As a rule the wound left by the foreign body heals in a day or two but usually leaves some kind of opacity also infection may supervene resulting in a simple or even a hypopyon ulcer (*See Fig* 1460 p 1043.) For this reason it is advisable to wash the eye out with some penicillin solution before covering it

Fluorescein A dye which stains green areas of the cornea denuded of epithelium.

Loupe: A small magnifying lens usually 8 or 10 × used for examining the cornea under oblique focal illumination. The binocular type is less powerful and is attached to the observer by a head band.

Hypopyon A collection of pus, usually sterile lying at the bottom of the anterior chamber

NON PENETRATING INJURIES

DIRECT WOUNDS OF THE CORNEA

The most common injury of the cornea is an abrasion that is, it consists in the removal of a portion of the epithelium by a scratch from some sharp object such as the finger-nail, the edge of a leaf a twig etc. The injury is extremely painful owing to the involvement of the terminations of the corneal nerves and also the spasm of the iris which results. There is lacrimation, injection (redness) of the eye and narrowing of the palpebral fissure

In order to make a careful examination, it is nearly always advisable to put a few drops of pantocaine into the eye

In extensive lesions the superficial defect is readily seen in the loss of polish and the slight difference in level between the abrasion and the surrounding cornea. Fine abrasions are often only seen when the lids are held apart for a time to allow the surface of the cornea to dry a little. The instillation of a drop of fluorescein (see p. 1041) will settle the question by staining the affected parts.

TREATMENT —The most important part of the treatment is to keep the eye tightly bound up with a pad and bandage In most cases—except in patients over 40 years of age where glaucoma is feared—a mydriatic e.g 0 5 per cent atropine ointment, or in slight cases 1 per cent homatropine is put in before bandaging

With this treatment the abrasion, as a rule soon heals by the epithelium growing over the defect, and if Bowman's membrane is not involved no scar is left. But a corneal ulcer or hypopyon ulcer may result from infection of an abrasion, especially if a mucocele of the lacrimal sac is present at the same time

Deeper wounds of the cornea may be incised or lacerated. The margins swell due to imbibition of tears, and become cloudy Later the epithelium grows over the defect, which is filled with scar tissue and the result is an opacity or nebula of varying density There may also be some consequent irregularity of the surface which gives rise to irregular astigmatism. The treatment of these wounds is the same as for an abrasion.

Recurrent Erosion.—This is the term applied to the recurrence of an abrasion, *without fresh trauma*, some weeks or even months after the original injury has healed On opening the eye one morning it becomes painful and waters. An area which stains with fluorescein is usually found at the site of the original abrasion. This is probably due to the fact that the new epithelium over the wound had never become completely adherent to its bed and thus was liable to become separated from such a slight cause as the opening of the eye in the morning

In some cases there is a recurrence of the symptoms without the formation of a superficial staining area in the cornea. In others, one or more vesicles occur at or away from the site of the original lesion. It is believed that some of these cases are allied to herpes corneæ and have therefore, a neuropathic basis.

TREATMENT —The eye is treated as for the original abrasion. It should, however be kept covered for some days after it has healed. In addition, a bland ointment, such as ung. acid. boric., or petroleum jelly is liberally applied to the conjunctival sac at night in order to prevent the lids from sticking and the patient is told to open his eyes very gently on waking in the morning In some cases the abrasion continues to recur It is then a good plan to curette it and apply pure carbolic acid. Ordinary vaccination with calf lymph may stop the recurrences. Contact X rays have latterly proved very effective As a prophylactic it is advisable to order a lubricant ointment to be inserted inside the lower lid every night for a period of a month or so after an abrasion.

WOUNDS OF THE CONJUNCTIVA

Wounds of the conjunctiva are usually accompanied by a good deal of ecchymosis. Otherwise they are of no significance.

Owing to the elasticity of the membrane however they tend to gape and consequently healing may be complicated by the formation of granulation tissue as occurs sometimes after operation for squint Where the edges are widely separated, therefore it is wise to bring them together with a suture

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Bowman's membrane A structureless layer lying between the epithelium of the cornea and its substantia propria.

NON-PENETRATING CONTUSION INJURIES

Such injuries may affect the eye directly at the point of impact or owing to the relative incompressibility of the tissues may injure the ocular contents indirectly at some distance from it. Injuries with a blunt instrument (e.g., the fist or the edge of a table) such as cause contusions, come usually from below and the outer side where the eye is least protected by the orbit.

The bulb is compressed and its tension raised. Whereas the outer fibrous coat (cornea and sclera) can withstand a considerable pressure, the middle and inner coats are far more easily injured, yet with sufficient force the fibrous tunic may be ruptured as well.

Hyphaema.—A very common result of a blow on the eye is a hæmorrhage into the anterior chamber. The blood settles down and is easily recognized as a red mass bounded above by a horizontal line.

TREATMENT.—The eye is tied up with a pad and bandage. If the hyphæma is large the patient is put to bed. Cold compresses ease the pain. Straining at stool must be avoided by attention to the bowels. The blood usually disappears rapidly, often without any ill effects. Not infrequently, however, when the blood disappears other injuries become visible.

Fig. 1436.—Iridodialysis. (*From Eugene Wolff's "Diseases of the Eye."*)

LESS COMMON INJURIES

Iridodialysis.—The iris may be torn from its attachment to the ciliary body, which shows itself as a dark crescent like a second pupil (*Fig.* 1436).

Dislocation of the Lens.—The pupil may be found dilated and inactive to light and accommodation. The iris may be tremulous as a result of *partial* or *complete dislocation of the lens* which normally supports it.

Partial dislocation of the lens may also be recognized by the fact that when the fundus is examined with the ophthalmoscope two pictures of it are seen—one through the lens and the other through the portion where no lens is present. Later the lens may become opaque.

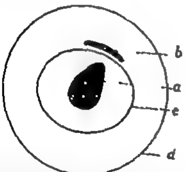

Fig. 1437.—Scleral rupture, right eye. Shows the situation of the most common type of rupture (right eye) as examined in daylight or by focal illumination. *a*, Pupil drawn upwards and towards towards the rupture; *b*, Site and common extent of the rupture just posterior to the corneoscleral junction; *c*, Corneal margin; *d*, Equator of the eye.

Hæmorrhage into the Vitreous.—This condition may be seen as a red mass by shining a light obliquely into the pupil, but often it can only be surmised by the fact that no red reflex is present on examination with the ophthalmoscope.

Hæmorrhage into the vitreous takes a long time—weeks or months—to absorb, but may eventually disappear without ill effects. Indeed there is a clinical aphorism which says, "Never despair of a vitreous hæmorrhage." But there may be accompanying detachment of the retina, or rupture of the choroid, recognized as a whitish crescent with pigmented borders usually to the outer side of the disc.

Rupture of the Globe.—The most severe result of a contusion injury is a rupture of the globe. The blow is severe and usually comes from below and the outer side where the eye is least protected. It may be from a fist or a thrust of a cane or cow's horn (a not infrequent injury among farmers). The rupture lies in the sclera, and is usually in the form of a crescent close to and parallel with the limbus. Often some of the intra-ocular contents, e.g., lens, vitreous, etc., are extruded through the wound. The iris in this region appears to be absent as if it had been removed at operation, i.e., by iridectomy (*Fig.* 1437).

Hyphæma: A collection of blood at the bottom of the anterior chamber.
Iridodialysis: Tearing of the iris from its peripheral attachment.

The conjunctiva over the rupture may not be torn and then the lens may form a mass under it (subconjunctival dislocation of the lens).

TREATMENT.—Most ruptures of the globe are so serious that immediate excision of the eye is the best treatment.

In certain cases, however, it may be possible to save the eye by cutting off the prolapsed iris, suturing the sclera, or bringing a flap of conjunctiva over the wound (see p. 1030).

PENETRATING OR PERFORATING INJURIES

In any injury to the eye it is extremely important to determine whether the wound is a perforating one or not, and if it is a perforating one, whether (1) there is a prolapse of the uveal (iris, etc.) or other tissue, and whether (2) a foreign body has been retained in the eye. Perforating injuries are always serious, as the injury may not only severely affect the function and form of the eye, but is prone to lead to infection or to sympathetic ophthalmitis. There is danger also of late results such as glaucoma, detachment of the retina, etc.

Signs and Symptoms of a Perforating Injury.—

1. Greatly diminished intra-ocular pressure is observed. This sign is extremely useful where the perforation is scleral and hidden by hæmorrhage and conjunctiva.

2. If the perforation involves the anterior chamber the latter disappears or becomes very shallow. Also the escape of aqueous may give rise to the statement sometimes made by the patient that he has felt "hot water" coming from the eye.

3. Prolapse of the intra-ocular contents takes place, usually part of the uveal tract which presents on the outside of the eye as a darkly pigmented mass (*Fig.* 1430).

Corneal Perforation.—This shows itself as a greyish area with swollen margins. In early cases there is no anterior chamber and the iris is therefore in contact with the cornea.

The extreme lowness or entire absence of tension constitutes one of the most important signs of perforation of the globe.

The diminution of vision will depend on the site of the scar and the amount of astigmatism produced.

If infection takes place other changes are seen. A hypopyon may appear and panophthalmitis may result.

Wounds of the Sclerotic. These may be obvious, but not infrequently are difficult to recognise. This is especially the case where the eye has been wounded through the eyelid. The bruised and swollen lid makes examination difficult and moreover blood under the conjunctiva may obscure the perforation. Reduction of ocular tension is the important sign. Large wounds are usually accompanied by prolapse of the iris, ciliary body, choroid, or vitreous.

Wounds of the Lens. Wounds of the lens result in a traumatic cataract and render the prognosis more grave. The entry into the lens of aqueous, or vitreous, causes it to become swollen, cloudy, and opaque.

The further history depends on the size of the break in the capsule and the age of the patient. If the wound is small, as in those made by a pin or needle, the subcapsular epithelium may grow over the gap and the cataract may cease to progress. This is also more likely to occur in the case of older patients, when the lens is more sclerosed. A greyish white scar remains in the capsule.

In larger wounds of the capsule the swollen and degenerate lens fibres make their way through the gap in the capsule and form flocculent masses in the anterior chamber, whence they are gradually absorbed. If the lens matter passes into the anterior chamber in great quantity it may block the angle and give rise to glaucoma. An increase of tension may also be produced by the swollen lens itself pushing the iris against the corneosclera.

In young people the lens may be entirely absorbed and only the capsule and its epithelium left.

Involvement of the Iris. One of the most important points to be determined in any perforating injury of the eye is whether there is prolapse of the iris (*Figs.* 1428, 1430) or ciliary body. *Prolapse of uveal tissue constitutes an indication for operation as soon as*

Uvea. A collective term including iris, ciliary body, and choroid.

expert attention can be procured since if left it greatly increases the risks of septic infection and of sympathetic ophthalmitis, and, at best greatly lengthens the time required for the eye to settle down

In certain fortunate cases, however the iris may become adherent to the wound and eventually remain as part of a leucoma adherens, i e., a white scar with iris adherent to it.

A prolapse of the iris presents on the outside of the eye as a darkly pigmented mass. The pupil is drawn up towards the wound and tends to become pear-shaped.

In very large wounds the ciliary body may prolapse or even the lens, choroid and retina, which entails the loss of the eye.

Treatment of Penetrating Injuries.—If the eye is so badly injured that no useful vision may be expected it should be excised at once

If useful vision is expected, and there is no indication of a metallic foreign body the wound is cleansed with cotton-wool. If there is prolapse of the iris (*Fig* 1459) it is

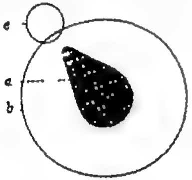

Fig 1458.—The appearance of the pupil in a case of penetrating wound at or near the corneo-scleral junction in which the iris has prolapsed. a, Pupil drawn towards the wound; b, Corneal margin; c The circle represents the situation of a bulge or prominence at the site of prolapse in examination by daylight or focal illumination. The prominence is usually black in colour (uveal pigment).

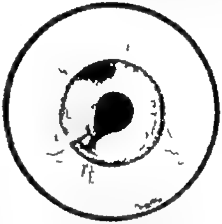

Fig 1459.—Incised wound of cornea, parallel with limbus in 7 o clock meridian. Pupil pear-shaped owing to prolapse of iris at one end

extremely important that this should be cut off (*see* ABSCISSION OF PROLAPSED IRI p. 1038).

Small wounds require no suture large and gaping wounds should be closed b sutures passing superficially through the sclera or by bringing a flap of conjunctiva ove the wound.

Atropine is put into the eye, which is tied up with a pad and bandage, and th patient is put to bed.

If the eye settles down nothing further need as a rule be done

If a traumatic cataract develops this may be needled in the case of a child or youn adult or extracted in the case of a patient over 30 years of age.

If the eye does not settle down as shown by continued redness and irritability it may as a rule be watched for two weeks before deciding whether it ought to be excise for fear of sympathetic ophthalmitis. If there is no perception of light, excision i indicated much earlier

SYMPATHETIC OPHTHALMITIS

Sympathetic ophthalmitis is a severe and often blinding inflammation of one ey which results from a penetrating injury of the other

The injured eye is spoken of as the exciting eye the other as the sympathizing eye. So long as the fibrous coat of the injured eye is intact, sympathetic ophthalmiti does not occur

Wounds of the corneoscleral junction are especially dangerous, for here portions c iris or ciliary body may become incarcerated in the wound The danger is further increase if the lens is wounded as well, and if there is a retained foreign body

Leucoma adherens A leucoma with uveal tissue adherent to it.
Limbus Corneoscleral junction.

Sympathetic ophthalmitis is much more likely to occur if the patient is a child.

The condition is preceded by sympathetic irritation as shown by watering and photophobia of the uninjured eye

It occurs most commonly from four to eight weeks after the injury Clinically it appears as a *quiet* iridocyclitis, hence the small grey dots of keratic precipitates (K.P) (*see* **Fig** 1474 p. 1046) must be looked for in the uninjured eye

Prophylaxis.—The surest way to prevent sympathetic ophthalmitis is to remove the injured eye and in cases where this is so damaged that useful vision cannot be expected there should be no hesitation also the patient will usually readily agree. But there are many cases in which one is justified in hoping to obtain a useful eye. The danger-signals of its affecting the other eye are the injured eye does not settle down; it remains irritable and red, and the tension as felt with the fingers is low In these circumstances resort should always be made to a blood-count a definite increase in the large mononuclears is held to be an indication of sympathetic ophthalmitis.

Treatment.—When once sympathetic ophthalmitis has started, except at the very onset it is extremely doubtful whether removal of the injured eye is of any benefit, and it should only be done if it is sightless. Indeed, cases have been known in which finally the vision in the injured eye was better than the other The iridocyclitis is treated with atropine hot bathings, etc. A course of salvarsan or allied preparations may do good. The antibiotics and cortisone have helped in some cases.

PANOPHTHALMITIS

Panophthalmitis is most commonly the result of a penetrating injury but it may occasionally be due to a metastatic choroiditis or retinitis coming on during pyæmia, especially in puerperal fever or in the case of children, in meningitis.

In a typical case the eye after a perforating injury seems to be recovering for 24–48 hours with perhaps only slight signs of inflammation Then quite suddenly there is a change for the worse The sudden change means that the septic material has reached the vitreous, through which it spreads with great rapidity In fact what is clinically a panophthalmitis is pathologically an abscess of the vitreous cavity

Not only do the local signs and symptoms become much worse but general symptoms appear There is a great increase in the pain and the vision rapidly goes. The lids become swollen and red. There is marked chemosis of the conjunctiva. The eye is red from conjunctival and ciliary injection. The purulent vitreous is recognized as a yellow glow or reflex when viewed by illumination. The fundus can no longer be seen. Pus soon appears in the anterior chamber (hypopyon) and the cornea becomes cloudy Later there is exophthalmos and limitation of movements of the eye due to involvement of Tenon's capsule.

As general symptoms there are fever headache drowsiness, and sometimes vomiting

If left to itself the abscess bursts, as a rule through the sclera near the limbus, leading eventually to phthisis bulbi.

Treatment.—In early cases, in which the condition arises as the result of operation wounds (e.g following the extraction of a cataract) it is justifiable to try to save the eye The edges of the wound are touched with a galvanocautery and the anterior chamber washed out with hydrogen peroxide. The sulphur drugs and antibiotics have latterly proved very useful and have saved many eyes which would otherwise almost certainly have been lost. These are best given by subconjunctival injection (p. 1044). Cortisone can be given by the same route and is sometimes very helpful, 10 mg 0·4 ml of the usual solution. If hyaluronidase is added, absorption is aided.

In the majority of cases, however after a perforating injury no attempt should be made to save the eye The eye is usually eviscerated and not excised owing to the possibility of meningitis resulting in the latter operation from the spread of infection along the optic nerve-sheath, though in early cases excision may quite well be performed.

ABSCISSION OF PROLAPSED IRIS

Instruments Speculum (**Fig** 1400) fixation forceps (**Fig** 1401), two iris repositors (**Fig** 1402) two pairs of iris forceps (**Fig** 1403), and de Wecker's scissors (**Fig** 1404).

Ciliary injection Engorgement of the vessels around the corneal margin.
Phthisis bulbi Shrinkage of the eyeball—not necessarily tuberculous.

Previous to the operation an attempt should be made to dilate the pupil [illegible] possible by means of atropine or better still 5 minims of mydricain may be injected [illegible] conjunctivally a few minutes before actually excising the prolapse

Anæsthesia.—In a young child a general anæsthetic is given, but [illegible] retro-ocular novocain is preferable The latter method often makes unnecessary [illegible] due to the patient having recently had a meal.

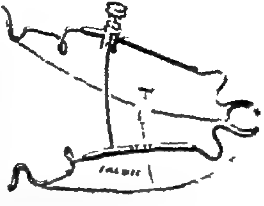

Fig 1460.—Ey[illegible]

Operation—The conjunctival sac is bathed and the speculum put in The prolapsed iris is seized with iris forceps held in the right hand and gently freed from the lips of the wound by an iris repositor The iris is now drawn out of the wound and seized by *a second pair of iris forceps* held in the left hand as close to the cornea as possible Having drawn on the iris again the surgeon cuts it off close to the cornea with the de Wecker's scissors held in the right hand. The remainder of the iris usually retracts into the eye but may need repositing

Fig 1461—Fixation forceps.

Fig. 1462.—Iris forceps.

Fig. 1464.—De Wecker's scissors.

Fig. 1462.—[illegible]

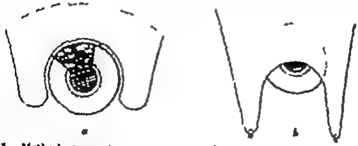

Fig. 1463.—Method of covering a gaping corneal wound with conjunctiva. *a* [illegible] the outline of the flap to be dissected up from below The dotted line shows the [illegible] which the conjunctiva is undermined upwards. *b*, Indicates the position of the [illegible] sutures have been inserted, drawing the flap down (like a blind) over the cornea [illegible]

Mydricain Atropine sulphate gr [illegible]
Procaine Hyd., gr [illegible]
Solution adrenaline 1–1000 B.P min. [illegible]
Boric acid, gr [illegible]
Sodium metabisulphite gr [illegible]
Aq for injection, min. v

Atropine 1 put in and the eye covered with a pad and bandage

Large and gaping wounds ought to be covered by a conjunctival flap. This should be prepared before abscission of the prolapse

The conjunctiva is divided at the limbus for half or more of its circumference and dissected back off the sclera. Thus a large flap of conjunctiva is fashioned to be brought over the wound after the abscission of the prolapse and held in position by stitches (*Fig* 1403).

EXCISION (ENUCLEATION) OF THE EYE

Indications.—

1 A painful blind eye

2 Perforating injury or ulcer (*a*) The eye is so badly injured that no useful vision is likely to result (*b*) Sympathetic ophthalmitis threatens.

3. Intra-ocular tumour

4. Malignant growth of the orbit

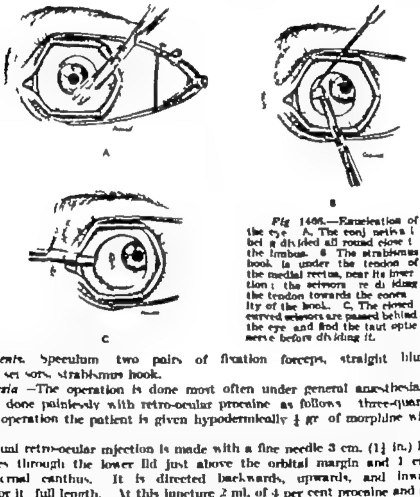

Fig 1406.—Enucleation of the eye A. The conjunctiva is being divided all round close to the limbus. B The strabismus hook is under the tendon of the medial rectus, near its insertion; the scissors are dividing the tendon towards the convexity of the hook. C, The closed curved scissors are passed behind the eye and find the taut optic nerve before dividing it.

Instruments. Speculum two pairs of fixation forceps, straight blunt-pointed (strabismus) scissors, strabismus hook.

Anæsthesia —The operation is done most often under general anæsthesia. It can however be done painlessly with retro-ocular procaine as follows three-quarters of an hour before operation the patient is given hypodermically $\frac{1}{4}$ gr of morphine with $\frac{1}{150}$ gr of atropine

The actual retro-ocular injection is made with a fine needle 3 cm. ($1\frac{1}{4}$ in.) long The needle passes through the lower lid just above the orbital margin and 1 cm. medial to the external canthus. It is directed backwards, upwards, and inwards, and pushed on for its full length. At this juncture 2 ml. of 4 per cent procaine and adrenaline is injected. After ten minutes the eye is bathed, the speculum put in, and a subconjunctival injection of procaine is given so as to produce a marked chemosis. After a few minutes the excision may be done quite painlessly

Operation The eye is bathed and the speculum inserted *The conjunctiva* is seized with fixation forceps, just above the upper limbus, and incised with the straight scissors. One blade of the scissors is now passed into the hole thus made and pushed as far as possible round one side of the cornea underneath the conjunctiva, which is then divided close to the limbus (*Fig* 1406). The conjunctiva is similarly divided close

Chemosis: Swelling of the bulbar conjunctiva.

to the limbus on the other side, and lastly it is divided below The conjunctiva is then dissected off the globe with small snips of the scissors as far back as possible, and at least to the equator (On this will depend the ease with which the eye will be removed.) In doing so the scissors are kept close to the globe and will necessarily open Tenon s capsule. A squint hook (*Fig* 1407) is now taken and passed under the superior rectus, which is divided between the hook and the globe, and towards the concavity of the hook. (The superior is done first, as it is the most difficult, especially if the other recti have been divided and in dividing it, care should be taken not to buttonhole the globe.) The other recti are similarly divided The squint hook is now passed all round to make sure that no rectus muscle has been left undivided.

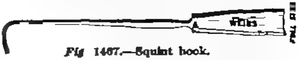

Fig 1407.—Squint hook.

The blades of the speculum are now widely separated and pressed backwards. If the recti muscles have been divided properly the globe will be dislocated forwards out of its socket. The eyeball is taken in the left hand and the closed curved scissors are passed behind it and the taut optic nerve is felt. The scissors are withdrawn a little, opened, and pushed on again to divide the nerve close to the globe (except in the case of a neoplasm, when it is cut as far back as possible). The eyeball is now drawn farther out of the orbit and the oblique muscles are divided. There is a variable amount of bleeding, which usually is easily stopped by means of pressure. No vessels are tied. The edges of the conjunctiva are brought together with fixation forceps. The lids are shut. An eyepad is applied, and over it is placed a medium-sized wad of cotton-wool. The bandage is applied firmly

As a modification of the above operation, a glass or other ball may be inserted into Tenon s capsule. This gives better movement to the artificial eye. The edges of Tenon s capsule and the ends of the recti muscles are included in a purse-string suture of catgut. The glass ball is introduced into Tenon s capsule by a special introducer and the purse-string drawn tight and tied. The conjunctiva is closed by interrupted silk sutures.

As a result of war experience, various types of implants have been used in order to provide a mobile artificial eye, and many satisfactory results have been obtained. The operation can be rendered practically bloodless if Foster s snare (*Fig* 1408) is used in place of scissors for dividing the optic nerve. To use this instrument, the oblique muscles must be divided as well as the recti. The loop of wire is slipped over the eyeball when it has been dislocated forwards and is gradually tightened when it passes the equator so as to slide backwards and grip the optic nerve. When this has been achieved, the wire is tightened further and left in situ for 30 seconds so as to compress the vessels in the optic nerve before giving the final twist to cut through it.

Fig 1408.—Foster's snare.

Evisceration of the Eyeball.—In this operation the cornea is completely removed and the contents of the globe are scooped out with a sharp spoon. Care is taken that no uveal tissue is left behind as sympathetic ophthalmia has followed this operation.

After-treatment.—The eye is kept tied up for two days in an attempt to diminish the bruising of the lids and cheek which sometimes follows an excision. After this the conjunctival sac is irrigated with normal saline from an undine once or twice a day depending on the amount of discharge, and 10 per cent albucid drops instilled. An eye-shade with gauze under it is worn after the third day

The patient may get up the day after the operation.

CORNEAL ULCER

An ordinary simple corneal ulcer appears as a grey spot on the surface of the cornea. Over it the cornea has lost its gloss or polish, which depends on an intact epithelium.

The actual loss of substance may be obvious, but in many cases it is not. An invaluable means of deciding this question is afforded by the following method : a drop of 2 per cent fluorescein (preferably from a glass rod rather than from a dropper) is applied to the conjunctiva just above the cornea. As it flows over *the surface it stains* the ulcer or an area devoid of epithelium a bright green. A few drops of 2 per cent

cocaine should then be employed to wash away the stain except from the affected parts. The cocaine also takes the pain away, giving the patient more confidence and thus making it easier for the surgeon to examine any lesion which may be present.

A corneal ulcer is accompanied by redness of the eyeball, which is usually ciliary in type, that is, it takes the form of a rose-pink ring around the cornea; but in the more superficial type of ulcer the vessels may be conjunctival only; often both types are present at the same time.

In cases where the ulcer has been present for some time a leash of superficial (conjunctival) vessels may be seen passing to it from the nearest point of the limbus.

A corneal ulcer gives rise to pain, lacrimation, and photophobia with its usual accompaniment of spasm of the orbicularis oculi, known as blepharospasm. All these, as well as the small pupil due to spasm of the sphincter pupillæ, are reflexly produced by irritation or stimulation of the terminals in the cornea of the first division of the fifth nerve.

The pain and photophobia are greater the more superficial the ulcer, since at this level there is irritation of the nerve fibrils, whereas in cases where ulceration goes deeper they are destroyed.

Blepharospasm is a common symptom and the condition is most marked in children with phlyctenular ulcers; here the lids are tightly shut; but in all cases the spasm is sufficient to cause a narrowing of the palpebral fissure, which is a characteristic sign of a corneal ulcer as well as of an abrasion or the presence of a foreign body on the cornea.

Treatment of Simple Corneal Ulcers.—Search should first be made for a possible cause, e.g., a foreign body, a conjunctival concretion, or a misplaced eyelash.

1. The next most important point in treating simple ulcers of the cornea is to keep the eye firmly covered, preferably with a pad and bandage. By fixing the lids the ulcer is put at rest, the symptoms of irritation are diminished, and healing is aided.

2. Atropine ointment 0·5–1 per cent is put into the conjunctival sac. (It is most important that the base of the ointment be petroleum jelly and not lard, which may be very irritating.) The guide to the number of times the atropine is to be used is the dilatation of the pupil. In certain cases, when the pupil dilates immediately, one application may be sufficient. The atropine overcomes the spasm of the iris, which is responsible for a large part of the pain, while the ointment also acts as an emollient and thus aids the healing of an ulcer. Where the pupil does not dilate, the atropine should be used twice daily or more often.

3. Hot bathing of the closed eye is always beneficial. The method is as follows: wrap a piece of cotton-wool around the bowl of a wooden spoon. With the patient bending over a large bowl of boiling water, the wool is dipped into the water and brought up close to the eye, which must be kept shut. When the heat can be borne the wool is allowed to touch the lids; when the pad cools it is dipped again, keeping the water as hot as can be borne by adding fresh boiling water; this treatment is continued for a quarter of an hour. Heat may also be applied by a small hot water bottle or an electric heater.

4. Whether the eye itself should be bathed depends on the amount of blepharospasm or discharge. In most simple cases it is unnecessary. In children, when blepharospasm is severe, more harm than good may come of it. The more copious the discharge the more often should the eye be bathed.

Simple lotions such as boric acid, 10 gr. to 1 oz., or hydrarg. perchlor. 1–10,000, should be used. Zinc sulphate is contra-indicated in most cases (except where the ulcer is caused by the Morax-Axenfeld bacillus) as it is too irritant. Nowadays antibiotics are often found effective, e.g., penicillin drops (2,500 units per ml.) every 5 minutes for 2 hours, then hourly for 12 hours and 2-hourly for 24 hours; chloramphenicol (1 per cent) ointment 2-hourly for at least 48 hours or drops (1 per cent) of the same substance 2-hourly for 2–3 days.

If much discharge is present the treatment must be modified. The bathing should be done more frequently, and 20 per cent protargol or 1 per cent silver nitrate should be applied to the palpebral conjunctiva once a day. The eye should not be tied up, but protected from the light by a shade or goggles.

Blepharospasm: Spasmodic closure of the lids.

Carbolizing the Ulcer.—If the ulcer has a sloughy base and an infiltrated edge (dirty, foul, or progressing ulcer), or is slow in healing, it should be carbolized by the following method: 4 per cent cocaine drops are put into the eye three times in 10 minutes, and before the last drop is instilled some 2 per cent fluorescein is employed to demarcate the ulcer. The eyelids are separated with the thumb and forefinger of one hand; by placing these not on the skin of the lids but actually on the lid margins, the globe can be steadied at the same time. The ulcer having been dried with a piece of blotting-paper, a fine camel's-hair brush is dipped into pure carbolic (taking care that there is no droplet at the end which may run over the cornea) and applied to the ulcer, paying particular attention to the infiltrated edge. Any excess of carbolic is dried up with the blotting paper. Atropine ointment 0·5 per cent is put in, and the eye covered. Carbolizing may have to be repeated at intervals of a day or more.

In severe cases the electric cautery may be used to burn the edge and floor of the ulcer, or the ulcer may be heated to a definite temperature by means of an electrically controlled thermophore.

If the ulcer continues to advance in spite of the above-mentioned measures, it may be necessary to free a neighbouring flap of conjunctiva and draw it over the ulcer.

If perforation is feared a corneal section (paracentesis) at the limbus, made with a keratome, may be resorted to in order to let out the aqueous and diminish the tension.

Treatment of Perforation.—

1. If the perforation is small the iris becomes applied to the back of the hole without prolapsing through it. In these circumstances the patient is put to bed, atropine is put into the eye, and a bandage is applied. If this is done, only a small anterior synechia usually forms which may later give way; in very favourable cases no synechia forms at all.

2. If a prolapse of the iris actually occurs this is cut off (*see* ABSCISSION OF PROLAPSED IRIS, p. 1038) or burnt off by means of the galvanocautery.

Hypopyon Ulcer or Ulcus Serpens.—

AETIOLOGY.—Hypopyon ulcer, i.e., a corneal ulcer accompanied by pus in the anterior chamber (*Fig.* 1409), is most commonly met with in aged debilitated persons, especially alcoholics, and is a disease rather of the poor than of the rich. It is more common in hot weather and during or after acute infectious fevers, such as measles, small pox, or scarlet fever. While in adults hypopyon ulcer is a very serious affection, in children it is much less severe and the prognosis is much more hopeful.

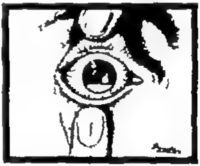

Fig. 1409.—Hypopyon ulcer of cornea, in the 4 o'clock meridian, adjacent to the pupil. Collection of pus at the bottom of the anterior chamber.

Hypopyon ulcer usually results from an infected abrasion, the infection being derived either from the body causing the injury, e.g., a piece of grit, or from the conjunctival sac. The latter is especially liable to be the source of the infection if there is a septic lacrimal sac (mucocele). The infective agent in 70–80 per cent of cases is the pneumococcus; staphylococci, streptococci, gonococci, etc., also may be responsible.

A typical clinical picture is as follows: an elderly road-sweeper, with a fondness for alcohol, gets a foreign body in the eye, or sustains an abrasion of the cornea from the scratch of a twig. In the course of a day or two a dull pain is felt in the eye and temple. The eye waters and cannot be used. The pain, as with many inflammatory conditions of the eye, is worse at night and keeps the patient awake. On examination the edges of the lids are found somewhat swollen and congested; the conjunctiva is markedly congested, the redness being both conjunctival and ciliary in type. There may be chemosis of the conjunctiva.

The typical hypopyon ulcer forms a greyish white or yellowish disc, situated near the centre of the cornea and having a depressed surface covered by slough. One edge of the ulcer, the advancing edge, is crescentic in form, more opaque than the rest, and yellowish

Synechia: Adhesion of the iris to the lens (posterior) or cornea (anterior).
Ulcus serpens: Corneal ulcer which creeps over the surface, usually associated with hypopyon.

in colour There is usually severe iritis, as shown by the posterior synechiæ discoloration of the iris, and intense ciliary injection.

TREATMENT.—The patient is ordered to bed. When the ulcer is first noted, the lacrimal sac is examined. If a mucocele is present, the sac is excised. The ulcer is kept clean by bathing with lotions of hydrarg perchlor 1–10,000, or quinine sulphate 0·5 per cent. Sulphamethazine, or another drug of this series, is administered systemically. Penicillin subconjunctivally or 2500 units to the ml used as drops, is a great help. This is best given as follows: crystalline penicillin 1 million units mydricaine min. 5; adrenaline 1–1000 min. 5 Aq dist. ad 1 ml. It should be made up freshly and injected subconjunctivally after 2 drops of pantocaine. Atropine ointment 0·5 per cent is employed to treat the iritis.

The aim of the treatment is to prevent the ulcer from extending, and with this end in view the galvanocautery should be resorted to the points being applied to the spreading *edge of the ulcer and lightly over the remaining area.*

Under the above treatment healing may result. If the hypopyon continues to increase, especially if the tension rises, it should be removed by paracentesis, or by means of Saemisch's section, which is carried out as follows the cornea is punctured with a narrow Graefe knife, the edge pointing forwards at one edge of the ulcer the knife is passed across the anterior chamber to make a counter-puncture in clear cornea just beyond the ulcer and the cut is made forwards to open the anterior chamber The viscid hypopyon is pulled out with iris forceps.

This course often saves the eye but a dense leucoma and poor vision frequently result.

ACUTE PRIMARY GLAUCOMA

Symptoms and Signs.—The patient has an attack of very severe pain which is felt in the eye itself and also radiates along the branches of the first and sometimes the second division of the fifth cranial nerve thus he may complain of pain around the eye, or down the nose of headache, and even toothache. The pain is so severe that the patient vomits—a very characteristic symptom and suggesting a bilious attack The vision is soon reduced to the level represented by the perception of hand movements. The patient's general condition is usually severely affected.

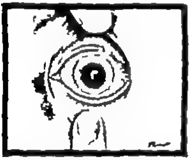

Fig. 1470.—Acute congestive glaucoma showing haze of cornea, pupil semi-dilated, and redness of the eyeball, most marked around the corneal margin.

The lids are slightly swollen and congested: the eye is red there is marked ciliary congestion and the conjunctiva appears a dusky red owing to congestion of the veins (*Fig* 1470). The cornea is steamy and anæsthetic The anterior chamber is shallow The pupil is oval, dilated, and fixed. No view of the fundus is possible owing to the condition of the cornea. The tension is raised, and the eye may become stony hard.

Treatment.—Eserine 1 per cent in oil is instilled into the affected eye every 15 minutes for an hour and as the other eye is predisposed and the anxiety may bring on an attack there as well a drop of eserine is put into it also. The instillations of eserine are then repeated every half hour The patient is given frequent hot-spoon bathings. Diamox[1] 250 mg. 6-hourly for 24 hours, and then twice daily by mouth, is very useful If the patient is vomiting it can be given intravenously

A dose of calomel 2 gr is given, followed by a saline draught four hours later or next morning

If after some hours there is no diminution of tension in the eye and the pupil is not constricted, operation is indicated. The essential aim of the operation is to remove a large piece of iris (broad iridectomy) as peripheral as possible Classically this is carried out as described in the section which follows, but the iridectomy may be performed by incision *ab externo* which makes this difficult operation a good deal easier and much safer

Leucoma: A dense white opacity of the cornea, usually the result of a perforating ulcer or injury

[1] Lederle Laboratories, Bush House Aldwych, London, W C.2.

Where it is impossible to do the operation, for instance, when no eye instruments are available a very good plan is to give the patient a retrobulbar injection of novocain and adrenaline.

By the continued use of eserine the patient may be tided over till the operation can be performed.

IRIDECTOMY FOR ACUTE GLAUCOMA

Anæsthesia.—Iridectomy may be done under general anæsthesia, or with retro-ocular (or sub-Tenon) procaine.

Instruments.—Speculum, fixation forceps (2 pairs) narrow (ground-down) Graefe knife (*Fig.* 1471) iris forceps, de Wecker's scissors, iris repositor.

Fig. 1471.—Graefe cataract knife.

Operation.—The surgeon stands at the head of the table. The eye is bathed and the speculum put in.

A stitch is placed in the superior rectus tendon. The eye is fixed by conjunctival forceps slightly below the inner end of the transverse diameter of the cornea. The point of the knife enters the sclera 1 mm. from the corneoscleral junction, and about 3 mm. above the transverse diameter. The knife passes very carefully across the periphery of the anterior chamber, great care being taken that the iris is not caught by it, for it is very easy to wound the lens. The counter puncture is made in sclera 1 mm. from the limbus. The surgeon now cuts upwards, the incision lying entirely in the sclerotic. A conjunctival flap is formed and turned down over the cornea.

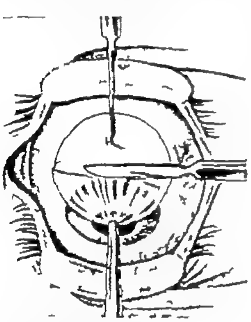

Fig. 1472.—The subconjunctival *ab externo* approach in glaucoma; the eye is fixed by a scleral hook, held in the left hand.

The assistant then rotates the globe downwards by means of the stitch in the superior rectus.

Fig. 1473.—Iridenclesis operation—conjunctival flap not shown for sake of clearness. A, Fold of iris prolapsed into scleral incision. B, The fold has been divided radially—the two halves impacted into the ends of the scleral incision and covered with a conjunctival flap.

The iris forceps held in the left hand is introduced closed into one angle of the wound and made to grasp a fold of iris close to the pupillary margin. This is drawn out of the eye and a radial incision made through it so as to include the pupil. The iris is drawn over to the other side of the wound, torn away from its attachment to the ciliary body and then finally cut off. The iris is repositied.

After-treatment.—The after treatment is much like that following cataract extraction. The eye is bathed with boric lotion and a drop of atropine instilled. It is, however, extremely important to instil a drop of eserine, 0·5 per cent, daily into the other eye, as the excitement of the operation is very liable to start an attack in it.

Incision ab externo.—The above is the classical operation for acute glaucoma. The iridectomy may, however, be done by incision *ab externo*. In this, one dissects down a flap as in a trephine operation (*Fig.* 1472). A stitch is inserted under the upper margin of the conjunctival wound, so as to engage the fibres of the superior rectus at its insertion (7·7 mm. from the limbus) and the eye is pulled gently downwards. Then with a sharp scalpel or a Bard Parker 15 knife placed at a tangent to the upper limbus and with the blade perpendicular to the globe, one makes an incision directly into the anterior chamber. This incision may be enlarged, if necessary, with narrow blunt pointed scissors. The iridectomy is then done as described above. An alternative procedure is to perform

iris inclusion (iridencleisis) Often after the sclerocorneal incision has been made a sausage-shaped fold of iris may prolapse into the wound—if not it can generally be made to do so by gentle pressure on the upper margin with an iris repositor and if this fails, it can be drawn out with forceps (*Fig* 1473). The fold is grasped with two pairs of forceps, a small nick made in it and the forceps separated so as to make a radial tear in the iris, reaching to the sphincter The portions of iris held by the forceps are impacted in the ends of the wound and the conjunctival incision united with a running suture.

Hæmorrhage can be troublesome but can be easily checked by touching bleeding points on the sclera with the point of a heated squint hook or with a cautery at dull red heat—provided the patient is not having an inflammable anæsthetic

This operation can also be used for chronic glaucoma with satisfactory results. In these cases it is advisable for the patient to have no miotic for 12 or preferably 24 hours before operation, otherwise there may be difficulty in causing the iris to prolapse Also, unless the eye is obviously draining freely after operation it should be massaged through the lower lid twice daily after instillation of a drop of 2 per cent pilocarpine and this should be continued for six months, until a permanent drainage channel is established.

IRITIS

Symptoms.—

1 Acute pain. The pain, which is usually severe, is felt in the eye but is also very often referred to the orbit around the eye and down the nose It comes on in exacerbations and is worse at night.

2. Photophobia and lacrimation, which are proportional to the pain.

3. Mistiness of vision in varying degree

Signs.—

1 The eye is congested. The redness is mainly due to the hyperæmia of the episcleral vessels, which lie deep to the conjunctiva and give rise to a rose-pink flush around the cornea. This is known as ciliary injection. The redness diminishes towards the fornix.

2. The iris is greenish and muddy and loses its markings.

3. The anterior chamber is deepened.

4 The pupil is small and irregular and reacts to light sluggishly or not at all. If a drop of homatropine and cocaine is put into the eye the pupil may often be seen after a time to become crenated or festooned, owing to the fact that portions of its circumference are bound down to the lens (*posterior synechia*) and are thus prevented from dilating (*Fig* 1474). As the pupil dilates, however the adhesions in early cases tend to break down, leaving a deposit from the pigment epithelium of the iris on the front of the lens. In some cases the whole pupil is bound down and may not dilate at all

Fig 1474.—Iridocyclitis, after instillation of atropine Showing circumcorneal flush, adhesion of part of iris to anterior lens capsule (posterior synechiæ) and dots of exudate on the back of the cornea (keratic precipitates or K P).

5 The ciliary region of the eyeball is very tender to the touch This sign must be elicited with great care by passing the finger over the closed eyelid from behind forwards. On account of the great pain which may be produced, this sign should not be used as a routine but only in case of difficulty in differentiating iritis from conjunctivitis; in the latter this sign is absent

Complications.—The main complication arises as a result of the whole pupillary margin becoming bound down to the lens (*ring synechia*). The aqueous, which normally drains from the posterior to the anterior chamber through the pupil can no longer do so As a result the iris is ballooned forward between its periphery and the adhesion to the lens, a condition known as *iris bombé* and the tension rises.

Exudate into the pupil may obscure vision.

There is also a great tendency to relapse especially if the patient does not rest the eye for a sufficient period.

Treatment.—Treatment is primarily directed towards breaking down the adhesions between the iris and the lens by dilating the pupil. Hence 1 per cent atropine is inserted either as drops or as an ointment every quarter of an hour for four or five times and

then four times a day. If this is not effective the atropine is combined with 2 per cent cocaine which aids dilatation.

The atropine is continued for at least a fortnight after the eye is white. After all inflammatory signs have disappeared, however, the quantity is gradually reduced. The pain, as a rule, is relieved by the atropine. The effect is supplemented by the application of heat to the closed eyelids by means of cotton wool wrapped around a wooden spoon, by a Maddox (electric) eye-warmer, or by other means, e.g. diathermy.

Protein therapy has been widely advocated, especially injections of milk. The milk is sterilised by boiling for three minutes and about 8 ml. injected subcutaneously over the recti abdominis muscles, or intramuscularly in the gluteal region or into the thigh opposite to that on which the patient usually sleeps. T.A.B. intravenously, starting with 25 millions, as fever therapy, is often extremely useful.

Latterly sulphapyridine and similar drugs have proved of great help in those cases due to the gonococcus, streptococcus, or pneumococcus. Sometimes 0·4 ml. cortisone subconjunctivally may act dramatically.

Both eyes should be rested and no reading permitted; dark glasses are ordered, with a pad of cotton wool over the affected eye to keep it warm. Alcohol is forbidden. Cold acts very adversely on the progress of cases of iridocyclitis; patients are therefore best treated in bed or at least confined to a room.

A Wassermann reaction is usually carried out and a search made for a focus of infection or other cause of the iritis.

ACUTE INFLAMMATORY SWELLINGS AT THE ORBITAL OPENING (Fig. 1475)

Hordeolum, or Stye, is a suppurative inflammation, a furuncle, of the sebaceous gland belonging to the follicle of an eyelash. It starts as a swelling in the line of the lashes and increases more or less rapidly, becomes red, and eventually the small abscess which

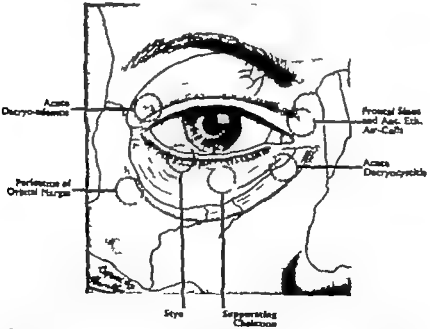

Fig. 1475.—To show the sites of acute inflammatory swellings at the orbital opening (Based on an illustration in Eugene Wolff's "Anatomy of the Eye and Orbit.")

has formed, points and discharges. Then the inflammatory signs quickly subside. Sometimes the stye is accompanied by œdema of the lid margin or swelling of the whole lid. In these cases the site of the hordeolum may not be obvious, but it may be found by passing the finger along the lid margin and detecting the point of most acute tenderness.

Hordeolum may cause enlargement of the pre-auricular gland. It is accompanied by a variable amount of pain, which may be severe.

Suppurating Chalazion.—A chalazion may become inflamed, causing great swelling of the lids, enlargement of the pre-auricular gland, and marked chemosis. Its site may be diagnosed by *finding the most tender point on the lid.* Such a suppurating chalazion usually discharges after a few days, especially if aided by hot fomentations.

Acute Dacryocystitis.—At any time in the course of a lacrimal obstruction the lacrimal sac may become acutely inflamed. The skin over the sac becomes red and much swollen, and the inflammation soon spreads to the lower eyelid. The abscess formation is accompanied by considerable pain and some fever

Treatment.—The abscess is opened by an almost vertical incision over the main swelling If left to itself the abscess usually opens below and to the outer side of the lacrimal sac, and either heals or forms a fistula.

Acute Inflammation of the Lacrimal Gland (Dacryo-adenitis) is curious in that it often subsides without suppuration. If an abscess does form, it discharges externally and a fistula may result. Dacryo-adenitis resembles orbital cellulitis clinically but with *general swelling of the lids there is induration and tenderness below the* outer part of the upper orbital margin. There is, as a rule only slight fever if any

Periostitis of the Orbital Margin is not uncommon in young children and is usually tuberculous. It may also be caused by trauma or syphilis. There is swelling of the lids and, later abscess formation. The abscess may subside or open leaving a sinus which leads down to bare bone Ectropion may result from a band of scar tissue which attaches the lid to the bone.

ORBITAL CELLULITIS

(*Figs.* 1476 1477)

Causation.—Orbital cellulitis is most commonly caused by ethmoiditis. The lamina papyracea of the ethmoid, which forms the main portion of the medial wall of the orbit

Fig. 1476.—Dissection of the orbit from above t show the relation of the frontal sinus and ethmoidal air-cells to the orbital periosteum (periorbita).
(*From Eugene Wolff Anatomy of the Eye and Orbit*)

Chalazion : Cyst of a Meibomian gland.

is, as its name implies, as thin as paper and forms a poor barrier against ethmoidal disease. Infection from the frontal sinus also occurs.

Furuncles, erysipelas, and other infections of the face are often to blame or the condition follows penetrating injuries or a septic operation. Rarely orbital cellulitis may occur in pyæmia, typhoid fever scarlet fever etc. and it has been known to arise in dental sepsis. Orbital cellulitis may also come from the parts around, i.e., from a panophthalmitis, or a lid abscess, or a lacrimal abscess pointing backwards.

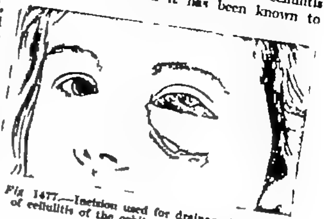

Fig 1477.—Incision used for drainage in a case of cellulitis of the orbit. Recovery followed.

Signs and Symptoms.—There is much swelling of the lids, so that the eye tends to be closed. Chemosis also is pronounced. There is proptosis of the eyeball and diminution in its mobility. Vision is often reduced due to pressure on or involvement of the optic nerve. If the optic nerve is involved anteriorly papillitis results, though this is not common. There is much pain and fever.

Treatment.—In the less severe cases the condition often subsides with the treatment of the nasal condition, the application of hot fomentations to the eye and the exhibition of sulphathiazole and similar drugs.

When an abscess actually forms and points usually at the upper and inner portion of the orbit, it should be opened by an extensive incision up and in or directly in along the orbital margin, and the abscess drained. Even if pus is not found the incision often does good (*Fig* 1477)

BURNS OF THE EYE

Burns of the eye are usually produced by molten metal steam strong acids or caustics such as lime or alkalis.

A not infrequent accident is a burn of the cornea from a curling iron, an injury which is very painful. It is treated as an ulcer with atropine ointment and covered with a pad and bandage.

Among the severer burns there is a great difference between those due to hot metal and those due to caustics. In the case of a metal burn one can determine fairly closely the extent of the injury but not so in burns produced by caustics. In the latter soon after the accident there is intense conjunctivitis and chemosis, but the cornea may appear clear except in the worst cases. Fluorescein will show the extent to which the corneal epithelium has been burnt off. After a few days a slough may form which may lead to ulceration of the cornea and perforation of the globe. If the bulbar and palpebral conjunctiva are involved, two granulating surfaces may be opposed to each other and join. The eyelid may thus be tightly united to the globe, a condition known as symblepharon.

With a lime burn the opacity of the cornea tends to become whiter and denser as time goes on, due to the formation of calcium carbonate particles.

With a molten metal such as lead the film of moisture on the cornea acts as a protection. It reduces the temperature and causes the lead to slide off into the conjunctival sac. Thus the cornea may be but slightly damaged while a solidified piece of lead may be found adherent to the conjunctiva or lashes.

Treatment.—In the case of burns due to caustics, if the injury is seen early the eye is bathed with large quantities of fluid preferably using weak alkali for acid burns (sodium bicarbonate 2 per cent) and weak acids for alkali burns (boric acid, 10 gr to 1 oz.). In emergencies these solutions will not be immediately at hand and the face should be immersed at once in a basin of water the eyes being opened if possible. Atropine ointment is put into the eye.

Papillitis: Inflammation of the intra-ocular portion of the optic nerve.
Symblepharon: Adhesion of the lid to the eyeball.

For lime burns, the pieces of lime having been removed, 10 per cent neutral ammonium tartrate is used. The eye is anaesthetized with 4 per cent cocaine drops three times in ten minutes, and then irrigated with the warmed tartrate solution, which is poured over the eye with an undine. The symptoms are rapidly relieved by this measure and the tartrate also helps to dissolve any particles of calcium carbonate which have formed, and thus tends to lessen the degree of opacity which may result.

In an attempt to prevent symblepharon, the point of a glass rod covered with petroleum jelly is passed across the upper and lower fornices once a day

SIMPLE DETACHMENT OF THE RETINA

Treatment.—The only effective treatment is by operation which consists in finding and sealing the hole or tear and letting out the subretinal fluid.

While detachments have been put back months after their occurrence there can be no doubt that the sooner they are done the better the prognosis.

Localizing the Hole.—This step may be easy or very difficult In some cases no hole may be found. Often some assistance may be afforded by the type of case and the history In high myopia there is most commonly a tear in the upper temporal quadrant in hypermetropia and emmetropia, in the lower temporal quadrant. If the patient states that the first flashes of light appeared in the lower nasal field, and that this was followed by a shadow in the same part of the field the hole is almost certainly in the upper temporal quadrant.

The sealing of the hole is effected by producing a plastic choroiditis, which causes the retina and choroid to adhere at the site of the hole. This is brought about by means of diathermy applied at several points to the surface of the sclera over the site of the hole or in a semicircle, the two ends of which are at the ora serrata by a ball or other surface electrode (Larsson's method) or by Safar's points, which actually pierce the sclera. In the former method it is necessary to make one puncture with a diathermy needle to let out the subretinal fluid. This is aided by a suction apparatus.

Operation.—Procaine, 2 per cent, and adrenaline solution is injected under the conjunctiva and under Tenon's capsule An incision more or less concentric with the corneal margin, and about 6 mm. distant from it, is made through the conjunctiva, which is then dissected back off the sclera To obtain adequate exposure it may be necessary temporarily to divide a muscle. Larsson's ball electrode is applied for 8 seconds with a current of 80 milliamperes. With Safar's method the current is passed for 2 seconds at 50 milliamperes and then the point is withdrawn.

The patient is put to bed in such a way that drainage of the subretinal fluid is easiest; thus, in a case with a hole on the temporal side of the right eye, the patient lies somewhat over towards this side. Both eyes are covered for a fortnight with just sufficient dressing to keep the eye clean and the pupil dilated with atropine. After this the patient is given special spectacles having only a central hole for vision.

PURULENT CONJUNCTIVITIS

Treatment.—The first thing to do in the adult is to prevent the other eye from becoming affected, bandaging the sound eye at once, or better excluding it by means of a Buller's shield (*Fig* 1478) In the baby in whom the disease is always bilateral this is not necessary

The advent of sulphonamides, and more latterly of penicillin and chloramphenicol, has revolutionized the treatment of purulent ophthalmia. It is, therefore, very important to start giving sulphathiazole sulphadiazine or similar compounds by mouth as soon as possible

Penicillin drops kept in a refrigerator (2500 units to the ml) should be instilled six or more times a day

Apart from this the eyes are bathed with normal saline a sufficient number of times to prevent pus from accumulating under the eyelids. In this connexion, separating the eyelids should be done with great care as the pus may be under pressure and squirt into the surgeon's or nurse's eyes. They should therefore wear protective goggles and preferably rubber gloves.

The lotion is applied by means of cotton wool or an undine may be used if handled with great care. The bathing washes away the pus and thus prevents its solvent or macerating action on the cornea.

A bowl of 1–10,000 perchloride and a supply of swabs are put near the bed so that the patient can wipe away the pus in the intervals of bathing

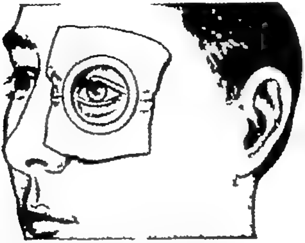

Fig. 1478.—Buller's shield for the protection of a healthy eye when the fellow eye is affected with purulent conjunctivitis.

TRICHIASIS OR INGROWING EYELASHES

Treatment.—If there are only a few eyelashes rubbing on the cornea they may be removed by means of a lash forceps (*Fig.* 1479). If a number of lashes are involved they are removed by electrolysis. Should there be any extension of the trouble a plastic operation is necessary

Fig. 1479.—Lash forceps.

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CHAPTER LXXXIX

THE EAR

By Francis Bauer, M.D (Prague) F.R.C.S.Ed. D.L.O
Ear Nose and Throat Surgeon North Liverpool Group of Hospitals

THE EXTERNAL EAR

Foreign Bodies in the Ear.—Small children sometimes insert beads, pebbles, peas, and similar foreign bodies into the ear. Adult patients with discharging and itching ears tend to forget pieces of cotton-wool and broken match-sticks, used for cleaning, in the depths of the auditory meatus. Children are usually brought by alarmed mothers as an emergency and treated as such, but it should be stated emphatically that unless the ear has already been injured by injudicious attempts at extraction of the foreign body there is no need for alarm or haste. Practically all foreign bodies can be removed from the auditory meatus by syringeing and this should be done in the first place and in the usual way as for removal of wax from the ear. Adequate assistance is required. The water must be warmed to body temperature to avoid giddiness from caloric stimulation of the labyrinth.

Only if the attempt at washing out the foreign body should fail (and this is very rare) is mechanical extraction required. It is not only useless, but dangerous to attempt this in a frightened and struggling child, and cases are on record where glass beads have been crushed and pushed into the middle ear through the tympanic membrane and even into

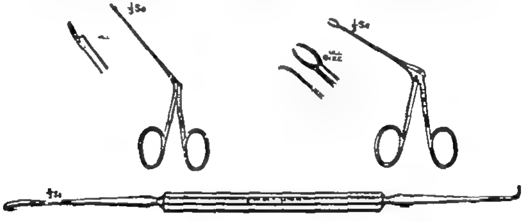


Fig. 1480.—Aural forceps with spud and hook.

the labyrinth in an ill-advised attempt at removal! A general anæsthetic is therefore necessary. This is one of the situations where a quick whiff of gas in the Casualty Department can lead to tragedy from inhalation of the contents of the stomach. It is therefore best to admit the child. After due preparation, a general anæsthetic is administered. Adequate illumination is essential. Suitable cupped forceps, or according to the shape and consistency of the foreign body a spud and hook (*Fig.* 1480), as well as a suction apparatus, should be available. Great gentleness is required in order not to push the foreign body beyond the narrow isthmus of the auditory meatus and not to damage the tympanic membrane. If a hook is used, the end must be insinuated between the foreign body and the meatal wall, turned and withdrawn, bringing the object with it.

If the foreign body has been pushed beyond the isthmus of the auditory meatus and cannot be removed in the way described, a small vertical incision is made into the auditory meatus from behind, close to the attachment of the auricle and the foreign body extracted under direct vision. After removal of the foreign body the tympanic membrane should be inspected carefully to make sure that it has not been damaged. The incision is closed

by two nylon sutures and the meatus packed lightly with ribbon gauze. If the tympanic membrane has been damaged, proceed as described in the next paragraph.

Traumatic Rupture of the Tympanic Membrane may occur by direct injury with a knitting needle, a hairpin, etc., or from pressure of air as in explosions, or by blows over the ear. The tympanic membrane can also be perforated *during syringeing* of the ear if the nozzle of the syringe is too long and is inserted too far into the meatus; if the nozzle becomes detached and is projected by the force of the water against the tympanic membrane; if the syringe, *instead of being filled* completely with fluid is partially filled with air which is then blown under pressure against the tympanic membrane; if the tympanic membrane is abnormally thin from previous scarring.

On rupture of the tympanic membrane severe pain is experienced, blood appears in the auditory meatus, and the patient complains of tinnitus. Deafness may be only slight. The appearance of a *recent* tear of the tympanic membrane is typical and important from the medicolegal point of view. It should be therefore noted specifically in the patient's record. The edges of a fresh perforation are ragged and blood-stained. In an old perforation the edges are *smooth and free from blood.*

In the management of a traumatic perforation of the tympanic membrane the one important aim is prevention of infection. If this objective can be achieved, the perforation is given a chance to heal spontaneously. Should infection supervene, inflammation of the middle ear is inevitable. The auditory meatus is not sterile, therefore the less manipulation in the auditory canal, the better; even the blood-clot should be left undisturbed. The meatus is dusted lightly with chloromycetin powder and sterile cotton wool inserted. A full course of systemic penicillin is given. *Syringeing is contra-indicated.* After two or three days the blood-clot or serum should be mopped out with sterile cotton-wool on an applicator. If in spite of these precautions infection supervenes, treatment as for acute otitis media (see p. 1064) should be carried out.

Furuncle of the External Auditory Meatus.—Patients with this condition often seek advice urgently because of intense pain. This is due to the rich nerve-supply of the skin of the auditory canal, which is tightly adherent to the perichondrium and devoid of subcutaneous tissue. The auditory meatus may be occluded by the swelling, arising from the *outer* cartilaginous part of the meatus (a swelling of the *inner* bony part of the meatus with *sagging of the upper and posterior wall, is suggestive of mastoiditis—see table below*). If the tympanic membrane can be seen it will be found to be normal. Not infrequently the auditory canal is occluded by the swelling and hearing is impaired thereby. If the meatus is opened by traction on the pinna, which causes pain, normal hearing will be restored. (In case of mastoiditis there is severe middle-ear deafness.) If the furuncle is situated on the *posterior* wall of the auditory canal, there may be post auricular oedema and consequently the pinna may be displaced forwards as in a case of acute mastoiditis. If the furuncle has burst recently it is probable that there will be a scanty, possibly blood-stained, discharge. A *summary of differential diagnostic signs* between furuncle and mastoiditis is given in the following table :—

Furuncle	Mastoiditis
History of boils elsewhere Sudden onset	History of a head-cold or tonsillitis followed by otitis media
Rare in children Pain on pulling the auricle and on mastication	Common in children No pain on pulling the auricle Pain on deep pressure over the mastoid process
Thick, scanty discharge, often blood stained	Mucopurulent profuse discharge
Swelling in the *outer* cartilaginous canal	"Sagging" in the *inner* bony part of the meatus
Hearing normal or little affected	Marked middle-ear deafness
X-rays show normal mastoid	Mastoid cells cloudy

Furuncle on the *anterior* meatal wall causes pre-auricular swelling and sometimes œdema of the lower eyelid. Otitis externa and pediculosis capitis predispose to furunculosis, because the patient tends to infect the skin by scratching.

Treatment.—Dry heat in the form of a hot water bottle is beneficial because it helps to bring the furuncle to a head. Systemic penicillin is justifiable because without it the condition may drag on and cause a number of sleepless nights. The auditory meatus is painted with 2 per cent mercurochrome solution in order to prevent re-implantation of organisms (staphylococci) when the furuncle bursts.

Penicillin ear-drops are useless in any ear condition and can only cause dermatitis. They should never be used. Chloramphenicol drops are a very powerful antibiotic but if used longer than a few days cause severe skin irritation (otitis externa).

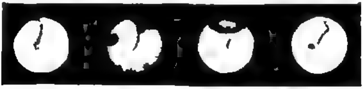
Incision under general anæsthesia with a narrow bladed scalpel through a slotted aural speculum is required occasionally when fluctuation is present and the boil is slow in bursting.

Post-auricular Adenitis.—The lymph-nodes overlying the mastoid process drain the scalp and are therefore often affected in infected abrasions of the scalp and in pediculosis capitis. Many a case of mastoiditis diagnosed on account of the post-auricular inflammatory swelling proves to be a case of post-auricular adenitis from head lice. The most important differential diagnostic sign which can be tested even in the most adverse conditions, is the hearing: in adenitis, it is unaffected, in a case of mastoiditis a severe degree of middle-ear deafness is found. Further differential diagnostic signs are: In adenitis there is no history of otorrhœa; in acute mastoiditis otorrhœa has been present for several weeks. In adenitis the tympanic membrane is intact and quiescent; in mastoiditis there is a perforation of the tympanic membrane with a pulsating discharge. A combination of otitis media and post-auricular adenitis from pediculi capitis does occur in patients whose standards of personal hygiene are low.

Treatment.—In addition to antibiotic therapy for the adenitis, treat the scalp by cleansing it with D.D.T. emulsion. If the inflamed lymph nodes break down and a fluctuating swelling develops, incision and drainage is required. In adenitis the abscess is subcutaneous; in acute mastoiditis (*see Fig.* 1483) it is subperiosteal.

THE MIDDLE EAR

Acute Otitis Media.—This condition is an emergency only in so far as the severe pain keeps the patient, very often a child, awake at night. The pain is due to pressure of the accumulated inflammatory exudate on the hyperæmic tympanic membrane. When examined at this stage the tympanic membrane is found red and bulging, at first usually in the upper quadrants. Later the landmarks (handle of the malleus) become indistinct and the whole tympanic membrane may bulge (*Fig.* 1481). Treatment consists in adminis-



A B C D

Fig. 1481.—A, Acute otiti media, mild. Con exity and injection of the tympanic membrane. (The right tympanic membrane is shown in each case.) B, Acute otitis media, severe. The membrane is bulging and scarlet, and shows hæmorrhagic bulla in the posterior part. C, Acut otitis media with bulging of the membrana flaccida. D, Herpes oticus; the vesicle lies near the umbo and just overlaps the handle of the malleus.

tration of sulphonamides or penicillin in full doses. As soon as the acute infection is under control the mucous membrane of the middle ear becomes decongested and the inflammatory exudate reabsorbed or expelled via the Eustachian tube. Myringotomy is hardly ever required as an emergency procedure as it used to be in pre-antibiotic days, and the author has not had to perform this operation as an emergency for a number of years. If the pain should continue and bulging of the tympanic membrane persist after 24 hours of intensive antibiotic therapy the infective organism is probably insensitive to the antibiotic and myringotomy would be justified.

Technique of Myringotomy.—Under general anaesthesia the tympanic membrane should be incised not simply punctured, in the postero-inferior quadrant (*Fig* 1482). This is done through an aural speculum with a fine, sickle-shaped bistoury or with a special harpoon-shaped angled knife (myringotome) under illumination from a forehead lamp or light reflected from a forehead mirror. Alternatively an auriscope with the examination lens removed and the small operating lens attached to the side of the speculum is quite satisfactory. As the landmarks are often indistinct the operator must make sure that he is not incising the posterior meatal wall instead of the drum, and that he is not scratching the surface of the tympanic membrane only but is penetrating all its layers. After the incision a swab is taken from the exudate or pus from the middle ear for bacteriological examination and a strip of ½-in. (1.2-cm) ribbon gauze is inserted into the auditory meatus to absorb the discharge. The gauze has to be changed frequently.

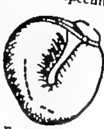


Fig. 1482.—Line of incision for paracentesis tympani. (Right ear.)

Myringotomy should not be performed lightly, because in some cases the incision in the tympanic membrane does not heal completely and a permanent perforation results. Therefore, if there is any doubt about the necessity for myringotomy, do not operate.

When the Tympanic Membrane has ruptured Spontaneously.—If the patient is seen only at a later stage of acute otitis media, when the tympanic membrane has ruptured spontaneously and the ear is discharging already, the treatment should again consist of administration of antibiotics and dry mopping of the discharge. If the mopping is not done frequently enough the discharge is likely to produce irritation of the skin of the auditory meatus (otitis externa) especially in children. In the acute stage aural drops should not be used.

The sensitivity of the infecting organisms must be tested by taking a swab from the discharge for bacteriological examination. One week of systemic penicillin followed by one week of sulphonamides is adequate even in severe infections, but it should be emphasized that even if the discharge has ceased and the appearance of the tympanic membrane has returned to normal, the hearing must be tested. If the hearing does not reach its normal level, expert otological opinion should be sought without delay. It may be that accumulation of a viscid, although sterile exudate is the cause of the residual middle-ear deafness. Unless this is expelled by inflation of the Eustachian tube or by myringotomy it is liable to become organized and eventually lead to adhesions, immobilization of the auditory ossicles and to permanent deafness.

Fig. 1483.—Examination from the back in mastoiditis. Note that the ear on the affected side is pushed forward.

Facial Paralysis occurring during the Course of Acute Otitis Media is due to neuritis of the facial nerve. This is not an indication for operation. The condition must be differentiated from herpes zoster of the geniculate ganglion in which facial paralysis is accompanied by excruciating pain and eruption of vesicles in the external auditory meatus and on the tympanic membrane (*Fig* 1481D).

ACUTE MASTOIDITIS

It is quite exceptional for an acute otitis media, which has been adequately treated, to develop into acute mastoiditis. It is important to realize that tenderness on pressure over the mastoid process is not synonymous with mastoiditis. The mastoid process is tender on pressure in every case of acute otitis media during the first two or three days of the attack and before rupture of the tympanic membrane has occurred; a high temperature in children is the rule. Only when tenderness and pyrexia appear in a patient with otorrhoea of several weeks' duration, and the discharge is purulent, pulsating, and increasing in amount, are we justified in diagnosing acute mastoiditis.

Even if the patient is seen for the first time only after acute mastoiditis (*Fig* 1483) has developed, there is no indication for an immediate operation. A swab is taken from the discharge and pending the result of bacteriological examination a massive dose of penicillin is given. This is changed to the appropriate antibiotic if the result of the sensitivity test demands it.

Acute mastoiditis occurs in the well pneumatized, cellular type of mastoid process, and pus therefore tends to find its way to the surface and may form a subperiosteal abscess; thus the possibility of intracranial complications is remote. A fluctuating collection of pus under the periosteum should be evacuated through a Wilde's incision (*see Fig* 1485A) which passes down to and includes, the periosteum. A small drainage tube is inserted for a few days.

CORTICAL (SCHWARTZE'S) MASTOIDECTOMY

Indications.—Very infrequently in acute mastoiditis. The writer has not found it necessary to perform cortical mastoidectomy as an emergency for several years. However it is probable that in some parts of the world where antibiotic therapy is not administered early the patient may arrive with sequestrum formation or impending intracranial complications, in which event a comparatively urgent operation will be necessary.

As will be described on p. 1060 the first steps of a modified radical mastoidectomy are identical with those of Schwartze's operation.

The instruments for mastoidectomy are depicted in *Fig* 1484. Bone wax may be required in order to stop troublesome bleeding from the bone. A suction apparatus is invaluable. A good illumination from a forehead lamp is essential. The hair behind the

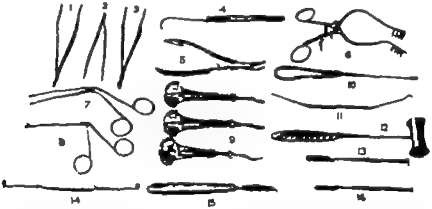


Fig 1484.—Instruments for the Schwartze operation. 1–3, Toothed dissecting forceps; 4, Aneurysm needle; 5, Jansen bone forceps; 6, Mastoid retractor; 7, Angular packing forceps; 8, Granulation forceps; 9, Hand gouges; 10, Retractor; 11, Pus seeker; 12, Mallet; 13, 16, Gouges; 14, Curette; 15, Faraboeuf's rugine.

Not shown: Scalpel, scissors, needles, 6 towel clips, and 12 hæmostats.

ear is shaved. The patient's head is steadied by means of a small sandbag placed beneath the opposite cheek.

Technique.—

1. A curved postaural incision is made (*Fig* 1483). Bleeding vessels are caught in hæmostats and ligated or coagulated. Care must be taken not to incise the temporal muscle in the upper part of the incision, as this causes troublesome oozing during the operation.

2. The periosteum is incised and reflected forwards and backwards with a rugine and a mastoid retractor is inserted (*Fig* 1483B). The mastoid process is cleared of a few muscular or tendinous fibres of the attachment of the sternomastoid muscle with scissors and the rugine.

3. Landmarks (*Fig* 1480) are now identified. The cutaneous posterior meatal wall is separated gently with a periosteal elevator so as to display Henle's spine at the junction of the superior and posterior bony meatal walls. Henle's spine indicates the level of the

mastoid antrum which lies about ½ in. (12 mm.) beneath the surface. The suprameatal crest (prolongation of the zygoma) marks the lowest limit of the dura of the middle cerebral fossa. Macewen's triangle is another valuable surface marking of the mastoid antrum. Macewen's triangle is formed by the posterior superior arc of the external bony meatus, and the tangents drawn through the highest and the most posterior meatal points (*Fig.* 1480 *inset*)

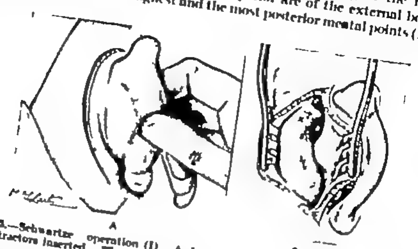


Fig. 1485.—Schwartze operation (I). A, Postaural incision. B, Periosteum reflected and retractors inserted. The marking for the mastoid antrum is shown by an X.

4. The tip of the mastoid process is identified. In cases with subperiosteal abscess, evacuation of the pus and exposure of the mastoid cortex will reveal a fistula from which pus is exuding leading into breaking-down mastoid cells. Using a hammer and a mastoid gouge of moderate width, the fistula is enlarged and followed, removing the mastoid cortex (hence the name 'cortical mastoidectomy') opening systematically groups of mastoid

Fig. 1486.—A hole has been drilled outward from the centre of the antrum parallel to the axis of the external meatus; note that the centre of the antrum is on a level with the top of the meatus. A, Foramen for mastoid emissary vein. B, Petromastoid suture. C, Supramastoid crest; D, Spine of Henle. *Inset*, Macewen's triangle.

cells and removing granulations. Pre-operative radiographs of the mastoids are a valuable guide to the distribution of mastoid cells in a particular case.

If no fistula is found removal of the cortex is commenced from behind forwards, in the direction of Henle's spine. Further cuts are made from the mastoid tip towards Henle's spine and from just below the supramastoid crest to the spine. Bone chips are removed and, using smaller gouges, the cavity is deepened until the mastoid antrum is reached. The operator must work in a dry field. An assistant removes blood either by suction or by mopping with ribbon gauze held in an angled forceps (see *Fig.* 1484 (7)). The antrum is

identified by the fact that it leads into the aditus. The visible landmark on the floor of the aditus is the whitish prominence of the lateral semicircular canal.

5. Once the antrum has been opened widely so as to secure adequate drainage systematic removal of mastoid cells is completed downwards, towards the tip of the mastoid, and backwards towards the sinus plate. On completion of the bone work a single smooth-walled cavity should result.

6. A small rubber drainage tube is inserted from the region of the antrum to the lower end of the postaural incision, and the incision is closed by interrupted mattress sutures.

During the next few days the discharge from the auditory meatus should diminish rapidly and cease completely. On the fourth post-operative day the drainage tube is shortened but the wound is not allowed to close completely until the meatus is dry.

SPECIAL CONSIDERATIONS WHEN OPERATING UPON AN INFANT'S EAR

There are important differences in the surgical anatomy of an infant's ear compared with that of an adult:—

a. In infants, where the bony auditory canal is not developed, the tympanic membrane is almost horizontal. This must be realized when myringotomy is contemplated.

b. During infancy the mastoid process is rudimentary and the stylomastoid foramen is near the surface unprotected by the mastoid process. Therefore in infants and small children a postauricular incision must not be carried beyond the tip of the mastoid, otherwise the facial nerve is endangered.

* * * *

Before closing this chapter a word of warning must be given about streptomycin in the treatment of aural infections. Streptomycin and especially dihydrostreptomycin, is toxic to the eighth nerve both to the vestibular and acoustic portion. The toxic effect is manifested by giddiness, tinnitus, and nerve deafness. Even an amount of streptomycin no larger than [illegible] G. daily for an adult is toxic if used for more than a few days. A safe daily dose for an adult is 1 G. (0.5 G., b.d.) for six days. Children tolerate the drug better than adults. In a patient whose hearing is already endangered by an infection of the middle ear the added risk of possible toxic nerve deafness is only justified under the exceptional circumstances when the responsible organism is not sensitive to any other antibiotic.

ACUTE-ON-CHRONIC MASTOIDITIS AND ITS COMPLICATIONS

While *acute* mastoiditis develops in cellular mastoids, it is a well-established fact that *chronic* mastoiditis tends to occur in patients with a sclerotic acellular type of mastoid process. This adds greatly to the technical difficulty of mastoidectomy since the antrum is small and placed deeply often in solid bone and the lateral sinus lies well forward where it is prone to injury.


A B

Fig. 1487.—A, Marginal posterosuperior perforation of the tympanic membrane. B, An attic perforation.

The patient's history concerning the duration of an aural discharge is not always reliable and in cases of doubt radiographs of the mastoids should be taken: these will display the degree of pneumatization present. When in a patient whose history and physical signs suggest acute mastoiditis, the mastoid is shown to be well pneumatized this is strong confirmation of the diagnosis. On the other hand if the mastoid is sclerotic it is probable that the case is an acute exacerbation of chronic middle-ear disease.

Chronic mastoiditis is characterized by continuous, although scanty discharge often of many years duration from a marginal posterosuperior or an attic perforation (situated in the pars flaccida of the tympanic membrane, *see Fig.* 1487) with granulations or cholesteatoma in the attic or mastoid antrum and possibly with caries of the auditory ossicles. Although its treatment is surgical, chronic mastoiditis as such does not require an emergency operation.

Chronic mastoiditis is painless. If however free drainage of pus becomes impeded by granulations or accumulation of cholesteatoma usually in the relatively narrow region of the aditus ad antrum or attic retention of pus under pressure follows and acute symptoms develop.

Pain in a case of chronic mastoiditis is always a danger signal because within a sclerotic mastoid process pus under pressure cannot find an outlet to the surface. Unless released by a timely operation it may find its way inwards and lead to intracranial complications such as extradural abscess, thrombophlebitis of the lateral sinus, meningitis, or brain abscess, singly or in combination. The second mechanism by which complications of chronic mastoiditis arise is the gradual increase in size of cholesteatoma which does not find an adequate route of escape outwards through a small attic perforation and by its *pressure* erodes the bony walls of the Fallopian canal, leading to facial palsy, or the bony *wall of the* lateral semicircular canal, causing labyrinthine irritation with giddiness, nystagmus, and vomiting. The giddiness increases with movements of the head; *the patient therefore*

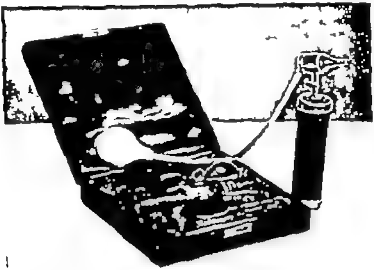


Fig. 1488.—Electrical auriscope with Siegle's speculum attached.

tends to keep the head resting quietly on the pillow. In case of erosion of the lateral canal the 'fistula test' is often positive: compression of air in the auditory meatus by means of Siegle's speculum (*Fig.* 1488) causes giddiness and nystagmus.

The signs and management of an *Extradural abscess* are described on p. 796.

Thrombophlebitis of the Lateral Sinus.—The lateral sinus, lying behind and below the mastoid antrum, may become affected by spread of thrombophlebitis from small veins of the middle ear or by the juxtaposition of an extradural abscess (perisinus abscess). It should be emphasized that if a case of lateral sinus thrombosis has been treated with antibiotics, the classical symptoms of this condition (sudden rises of temperature to 103 or 104 F followed by rigors and profuse sweating with comparative well being in the intervals) may no longer appertain. Instead, a comparatively moderate rise of temperature, aching in the ear, and tenderness, with possibly induration along the course of the internal jugular vein (continuation of the sigmoid sinus), with torticollis are often the only signs of this serious complication.

Queckenstedt's test is useful for confirmation of the diagnosis. If during the performance of lumbar puncture the internal jugular vein on the opposite side is compressed, the pressure of the cerebrospinal fluid, as indicated by a manometer rises, but if the lateral sinus is thrombosed and the affected side is compressed, there is little or no elevation in pressure.

Cortical Venous Thrombosis.—Thrombosis may spread to the tributaries of the dural sinuses, causing dramatic symptoms of focal epilepsy and hemiplegia.

Gradenigo's syndrome (otitis media associated with homolateral abducent palsy and deep-seated *retro-orbital pain*) which was formerly attributed to osteitis of the apex of the petrous pyramid (petrositis), is now considered to be due to thrombophlebitis of the inferior petrosal sinus (*C. P. Symonds*). *Both the inferior* petrosal sinus and the abducens nerve leave the posterior cranial fossa in a narrow sheath of dura mater (Dorello's canal), where the nerve may be compressed by the distension of the sinus, containing infected blood-clot.

Thrombosis of the *superior* petrosal sinus causes neuralgic pain in the distribution of the trigeminal nerve by irritation of the Gasserian ganglion.

Antibiotics alone cannot cure any of the complications of chronic mastoiditis enumerated above and are dangerous in so far as they may cause delay of an urgent operation. Thus, to summarize, in a patient with *chronic* mastoiditis earache without pyrexia is ominous, with pyrexia it calls for an immediate operation even in the absence of facial palsy, labyrinthine irritation and signs of a developing intracranial complication (extradural abscess, meningitis, cerebral abscess). In these cases drainage of the retained pus and removal of cholesteatoma is essential. This will entail opening the mastoid antrum (antrotomy) as an urgent measure.

In cases of *bilateral* chronic suppurative otitis media it is necessary to decide which ear is the seat of acute-on-chronic mastoiditis. If the patient is fully conscious this decision does not present any difficulty. In disorientated patients with intracranial complications it may be a problem. If both middle ears present similar pathology it is safe to assume that the ear which was the site of recent pain is the offending one. Even in an unconscious patient it is often possible to detect signs of fomentations and poultices, which were applied to one of the ears previous to his admission to hospital.

TECHNIQUE OF THE MODIFIED RADICAL MASTOIDECTOMY

After general intratracheal anæsthesia has been induced the retro-auricular tissues are infiltrated with a few ml. of saline-adrenaline solution in order to reduce hæmorrhage from the soft tissues (5 drops of 1–1000 adrenaline per 100 ml. of saline). As considerable pressure is required for the injection, a dental syringe will be found very useful. Be careful not to inject into the region of the stylomastoid foramen because infiltration of this region is wont to lead to an unpleasant, although transient, paralysis of the facial nerve. With the aid of an aural speculum the tympanic membrane or its remains is inspected, pus and debris are sucked out and a pledget of cotton wool, soaked in adrenaline-saline solution, is inserted into the auditory meatus in order to reduce subsequent bleeding from granulations in the middle ear. The first four steps of the operation are much the same as for cortical mastoidectomy (*see* p. 1050). After insertion of the mastoid retractor the soft tissues of the posterior meatal wall are gently separated from the bony canal and a pledget of wool soaked in adrenaline solution is inserted between the elevated soft tissues and the bony canal and left there during the excavation of the bone, in order to reduce subsequent oozing. As it is known that we are dealing with a sclerotic mastoid, do not look for mastoid cells but seek directly the mastoid antrum. Again the guides will be the spine of Henle and Macewen's triangle (*see Fig.* 1480). As the bone is hard, the gouges must be sharp. In case of difficulty in locating the antrum it is preferable to keep rather too high than too low, because exposure of the dura of the middle fossa has no untoward consequences, whereas if the excavation is made too low before reliable landmarks are identified, the integrity of the facial nerve is endangered. Depending upon the condition for which the operation is performed, on opening the mastoid antrum pus under pressure may well up or a cholesteatoma or granulations appear. A swab from the pus is taken for bacteriological examination and sensitivity tests. Pus or cholesteatomatous debris is aspirated. A seeker (*see Fig.* 1484, 11) is now introduced into the mastoid antrum and with its aid the cavity is gently explored backward and downwards, upwards and forwards, in order to determine its size and direction. The exploration *forwards* should be especially gentle in order to avoid dislocating the incus, should it still be intact. According to the information derived from the use of the seeker, the opening into the antrum is now enlarged with a small gouge until the whole cavity is fully displayed. We are now in a position to uncover the dura of the middle fossa above, if an extradural abscess is suspected (*see* p. 796) or the lateral sinus behind and below the mastoid antrum, if thrombophlebitis of the lateral sinus (*see* p. 1059) has been diagnosed.

In case of **Thrombophlebitis of the Lateral Sinus** the overlying bone (the "sinus plate") must be removed cautiously with a moderate-sized gouge to allow inspection of the outer wall of the sinus over an area of about ¾ in. (2 cm.). The use of nibbling forceps in the proximity of the lateral sinus is dangerous, because it is easy to injure this large blood channel with a splinter of bone. The ensuing venous hæmorrhage may be alarming. Should this mishap occur, a strip of gauze is packed over the site of the puncture and there it is kept pressed in position while the surgeon removes a piece of the temporal muscle, the

size of a *thumb nail*. The gauze is withdrawn quickly and replaced by the patch of muscle, which is pressed firmly over the bleeding spot for several minutes. The area is then repacked with ribbon gauze.

No packing must be placed into the sinus itself. On completion of the operation the end of the gauze is left protruding from the wound, which is left unsutured, while the rest of the cavity is packed with BIPP gauze. When the gauze is removed after about six days it will be found that no further bleeding from the lateral sinus occurs.

Should the postaural skin incision prove inadequate for an easy access to the lateral sinus, it can be enlarged by an auxiliary incision at right angles to the first in the direction of the torcular.

Sometimes the lateral sinus is found to be covered by granulations, its wall may be thickened or frankly discoloured, greyish-green and gangrenous or yellowish and containing blood-clot or frank pus. In case of doubt its content should be explored by aspiration with a needle, attached to an empty syringe, care being taken not to penetrate the opposite wall of the sinus. If fluid blood or uninfected blood-clot is found, the sinus is left undisturbed because clotting of blood is Nature's effort to localize infection. The use of heparin or other anticoagulants *is therefore contra indicated.* Should *it contain pus, the lateral sinus is* incised and the pus evacuated by suction and mopping.

Ligation of the Internal Jugular Vein.—This is not advocated as a routine measure. Only in the exceptional case, where temperature and rigors continue after an operation on the lateral sinus and when the operator is certain that there is no retention of pus within the skull, must it be assumed that infective thrombi are breaking off in the distal part of the sigmoid sinus. A positive blood-culture would confirm this suspicion. Only in these *circumstances or when metastatic lung abscesses develop and the infective organisms* prove to be insensitive to antibiotics, is ligation of the internal jugular vein indicated.

Technique.—The greater cornu of the hyoid bone is located by palpation. An incision 4 in. (10 cm.) long is now made, centred on the greater cornu, along the anterior border of the sternomastoid muscle. The incision is deepened and the cervical fascia incised. The sternomastoid is retracted backwards, the carotid sheath displayed and opened carefully. The entry of the common facial vein into the internal jugular vein is identified, the internal jugular is isolated by blunt dissection and a catgut ligature on an aneurysm needle is passed around it *above* the point of entry of the common facial vein and tied. The wound is sutured and a dressing applied.

If **labyrinthine irritation** was the indication for the emergency operation, the lateral semicircular canal must be carefully inspected, because this is the part of the labyrinth most exposed and therefore most commonly affected by the pressure of cholesteatoma.

Labyrinthine fistula presents as a dark (brownish or black) discoloration of the normally white prominence of the bony lateral semicircular canal. The cholesteatoma should be removed, *but the fistula itself is not interfered with.* Once the pressure of the cholesteatoma has been relieved and drainage into the auditory meatus restored, the fistula in the bony canal will heal spontaneously and the symptoms of labyrinthine irritation will rapidly subside. Operations on the labyrinth as an emergency procedure are never justified.

The purpose of an emergency mastoidectomy is to evacuate retained pus or to relieve pressure of a cholesteatoma eroding the bony Fallopian canal or the lateral semicircular canal, and at this stage of the operation the surgeon should pause and consider whether or not this purpose has been achieved. *The remaining steps of a modified radical or radical mastoidectomy are not an emergency procedure* and may be completed later, in 2–3 weeks time. Especially if the operator is not skilled in otological surgery, he will be well advised to discontinue the operation at this stage, pack the wound lightly with ribbon gauze soaked in BIPP or acriflavine emulsion, and leave the incision unsutured. (Do not forget to remove the pledget of cotton-wool from the auditory meatus and from the space between the cutaneous and bony posterior meatal wall.) Once adequate drainage is assured the general surgeon should not remove the auditory ossicles and remnants of the tympanic membrane lightly, as was practised formerly in the classical radical mastoidectomy. At present plastic operations aiming at reconstruction of the middle ear, damaged by suppuration, and restoration of hearing (tympanoplasty) are under trial. These reconstructive operations are facilitated considerably if there is even a remnant of the tympanic membrane present. Its removal may prejudice the patient's future chances of having some useful hearing preserved.

The remaining steps of radical mastoidectomy and its modifications (removal of the bony bridge, lowering of the facial spur and cutting of the meatal flap) are beyond the scope of the general surgeon, and are therefore not described in this work. Indeed, they are never absolutely essential at the time of an urgent operation to save life in a case of acute-on-chronic mastoiditis.

Local Anæsthesia in Mastoid Surgery.—In some Continental clinics the surgeons prefer to employ local anæsthesia only, using 15–20 ml. of 1 per cent procaine solution for the postauricular injection and 5 more ml. for injection into the anterior meatal wall. Heavy premedication is necessary in addition. In cases of increased intracranial tension (e.g. cerebellar abscess) where there is considerable risk that general anæsthesia would cause a further dangerous rise in intracranial pressure, after evacuating the contents of the abscess through burr holes under local anæsthesia drainage of the mastoid antrum under local anæsthesia has obvious advantages.

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CHAPTER XC

THE NOSE, THE NASAL SINUSES, AND THE PHARYNX

By Cecil I. Mallay, B.Ch., F.R.C.S. Eng., F.I.C.S.

Surgeon, Metropolitan Ear, Nose and Throat Hospital, London

THE NOSE

EPISTAXIS

The Arterial Supply of Each Nasal Cavity is derived from both the external and the internal carotid arteries.

The external carotid artery is responsible for the arterial supply of that part of the nasal cavity lying below the upper border of the middle nasal concha. The terminal branch of the maxillary artery (*Fig.* 1489 A) is the sphenopalatine artery—a comparatively large vessel—that enters the nasal cavity through the sphenopalatine foramen, and after bifurcation supplies the lower part of the septum and the corresponding portion of the lateral wall of the nose. The septal branch anastomoses with the septal branch of the superior labial artery and the greater palatine artery, both of which are derived from the external carotid artery.

The internal carotid artery provides the arterial supply for the upper part of the nasal cavity. *Within the orbit the ophthalmic artery gives off the anterior and posterior* ethmoidal arteries (*Fig.* 1489 C) which enter the nose through their respective foramina

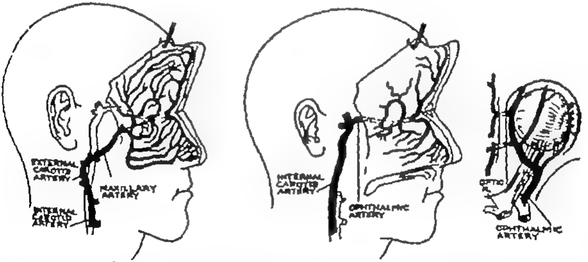


Fig. 1489.—The arterial supply of the nasal cavity. (*After R. T. Barson.*)

and are distributed ultimately to the upper part of the septum, the upper part of the lateral wall (*Fig.* 1489 B), and to the ethmoidal cells. It is stated that there is a fairly free anastomosis between the ethmoidal arteries (internal carotid) on the one hand and the sphenopalatine artery (external carotid) on the other.

The above account exhausts the arterial supply of the nasal cavities proper, but the blood-supply of the *nasopharynx* must not be omitted. This is richly supplied by the pharyngeal and pterygoid branches of the maxillary artery. These anastomose with branches of the facial artery and the ascending pharyngeal artery, thus forming the naso-pharyngeal plexus.

Source of Bleeding.—

Anterior Bleeding.—In about 60 per cent of all cases of epistaxis the source of the hæmorrhage is from varicose veins of Kiesselbach's plexus (*Fig.* 1490) situated in Little's

area (*see Fig.* 1401) on the antero-inferior portion of the cartilaginous septum. Bleeding from Little's area is comparatively slight in children, but it is more severe in adults. Rarely the bleeding point is higher up, in which case the hæmorrhage comes from the anterior ethmoidal artery or vein.

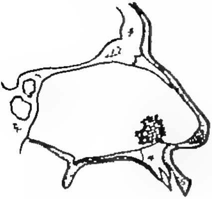


Fig. 1400.—Kiesselbach's plexus.

Posterior Bleeding.—Nearly always the patient is an adult. The hæmorrhage arises from either the posterior part of the lateral wall of the nasal fossa or from the septum. The bleeding is often arterial and emanates from a branch of the sphenopalatine artery.

Aetiology.—In a large percentage of cases no cause for the bleeding (see Table) can be found, in which case, if the bleeding is coming from Little's area, picking the nose—epistaxis digitorum—is the probable explanation. In any event, when blood issues solely from one nostril, the cause is almost certainly local to that side of the nose.

The blood may escape in drops, or pour out so profusely[1] that several pints are lost rapidly. Usually epistaxis due to cardiovascular disease commences with a sudden and severe hæmorrhage. At this juncture it is helpful to be able to call to mind a *Table* of possible causes of epistaxis.

CAUSES OF EPISTAXIS

TRAUMA	HIGH ARTERIAL PRESSURE	HIGH VENOUS PRESSURE	ATMOSPHERIC PRESSURE
Blow on the nose Fractured nasal bone Fractured base of skull Post-adenoidectomy After intranasal operations	Essential hypertension Arteriosclerosis Renal disease	Emphysema Bronchiectasis Chronic bronchitis Whooping-cough Mitral stenosis	Flying Caisson disease Mountaineering
SPECIFIC FEVER	NEOPLASM	BLOOD DYSCRASIA	LOWERED PROTHROMBIN
Typhoid Paratyphoid Influenza Scarlet fever Measles (Also rheumatism in children especially at onset of acute episode)	Multiple hereditary telangiectasia Malignant polyps Nasopharyngeal angio-fibroma Carcinoma of the antrum Sarcoma of the maxilla	Purpura Hæmophilia Aplastic anæmia Leukæmia	Liver disease Anticoagulants AVITAMINOSIS Scurvy Vitamin C lack

In every case where the cause of the hæmorrhage is not obvious the urine should be tested for albumin, and the blood pressure taken. By the time the doctor arrives many hypertensive patients are found to have a normal or low blood pressure as the result of shock due to hæmorrhage.

When an older person has a leaking blood vessel the vessel is liable to gape because of sclerotic changes in arteries and veins; for the same reason bleeding in older persons tends to recur.[2] Deficiencies in the clotting mechanism of the blood are seldom contributing factors in nasal hæmorrhage. Of 212 patients with severe epistaxis treated at the Mayo Clinic, in nearly all the bleeding commenced while the patient was at rest or asleep (O. E. Hallberg).

[1] Epistaxis, particularly that due to posterior bleeding, is often followed by mostly hæmatemesis due to vomiting swallowed blood.

[2] In hypertensive patients, packing the nose hurriedly has been followed (when the blood-pressure rises) by cerebral hæmorrhage (*M. Ellis, E. Watson Williams*).

Age of the Patient.—Epistaxis increases in frequency from the third year until puberty; it then becomes much less frequent until late middle life, by which time hypertension and arteriosclerosis are wont to have made their appearance. No less than 40 per cent of patients suffering from epistaxis are over 60 years of age, and 65 per cent of these suffer from hypertension (O. E. Hallberg).

From a practical standpoint the treatment of epistaxis can be divided into that occurring in young persons and children, and that occurring in older and hypertensive patients.

Epistaxis in Young People and Children is due to *venous* bleeding originating in Little's area.

First-aid Treatment.—The patient sits upright, and with the forefinger of the corresponding hand compresses the ala nasi against the nasal septum for ten minutes. This treatment is uniformly successful in stopping the hæmorrhage, but more often than not it recurs with the next bout of sneezing.

Elective Treatment is either by thermocautery or by mechanical cauterization. Either method requires good illumination and a local anæsthetic. A pledget of cotton-wool soaked in a solution of 10 per cent cocaine with an equal amount of adrenaline 1–1000, and squeezed until it is only just moist, is inserted between the anterior third of the nasal septum and the inferior concha. The patient compresses the ala nasi against the nasal septum with his forefinger for ten minutes. The pledget is then withdrawn. If the skin of the vestibulum nasi, which is not anæsthetized, is protected, the nasal mucosa now numb and the veins of Little's area (*Fig.* 1491) can be cauterized. A large *aural* speculum is inserted into the nostril, thus protecting the whole circumference, and revealing only the septal mucosa of Little's area. The platinum loop of a thermocautery is heated to cherry red, and the large veins at the periphery of Little's area are sealed off one by one, starting at the floor of the nostril. The cautery must be hot enough so as not to adhere to the mucosa (otherwise renewed bleeding will occur), yet not too hot (otherwise the mucosa will be cut through). The patient is warned that he will smell burning, but he is reassured that he will not experience pain. The actual process of cauterization should not exceed a few seconds. No special after-treatment is required, but the patient is exhorted not to pick the scab. If the nose itches, a little petroleum jelly should be applied. Should a thermocautery not be available, a small amount of 50–100 per cent trichloracetic acid is applied with the tip of a probe until the mucosa becomes white. The surplus acid must be mopped up carefully.

Fig. 1491.—Site of bleeding from Little's area, which is situated on the antero-inferior portion of the septum. (*From A. Logan Turner's Diseases of the Nose, Throat and Ear.*)

Epistaxis in Adults originates from an arteriosclerotic *artery*, which may be situated anywhere in the nasal cavity.

First-aid Treatment.—Digital compression described above can be tried, but it is not often successful, in which event the patient should not lie down, but be told to sit in a chair. If bleeding is severe, he should lean forward and let the blood drip into a bowl placed upon his knees. He may say that he feels faint, but almost never does he lose consciousness. To lean forward farther still counteracts the effects of a fall in blood pressure.

As soon as the opportunity presents, the nose is inspected with a view to ascertaining if the bleeding is from Little's area. If it is not, by drying the cavity or better, with the use of a sucker, it is often possible to determine from what part of the nasal cavity the blood is issuing.

In a series of 80 cases of epistaxis associated with hypertension, O. H. Killen found that the bleeding point was:—

Posterolateral in 23,
Septal in 12,
In the roof in 11;

in the remainder the exact site of the bleeding could not be determined.

Elective Treatment.—When it is in an accessible area of the nasal septum, the bleeding point appears as a little reddish-brown prominence projecting above the surrounding mucosa. If seen, the artery is cauterized under local anæsthesia in the same way as described for venous bleeding. Should the artery be situated elsewhere, and cannot be seen, the plan of treatment is as follows:—

a Trotter's Method: The patient is propped up in bed, inclined comfortably to one side. A large nest of wool is so arranged that he can dribble into it. A dental prop, or better a London Hospital airway (*see Fig* 1149, p. 820) is placed between his teeth. The patient is exhorted not to breathe through his nose or to swallow. A substantial dose of morphine is administered. Blood transfusion is given as required. Vitamin K_1 can be administered, e.g. synkavit[1] 1 ml. (10 mg.) intramuscularly. In children vitamin P from lemon peel (rutin[2]) 60 mg. t.d.s. by mouth, is valuable.

The great advantage of this method is that complications resulting from packing do not arise, whereas with packing more than 30 per cent of patients develop complications, notably sinusitis, blood in the middle ear (which frequently leads to otitis media), and infection of clot sealing the bleeding vessel, and consequent secondary hæmorrhage. In 80 patients suffering from epistaxis associated with hyperpiesis admitted to the Royal Infirmary, Newcastle upon Tyne, 70 per cent. were treated successfully by employing Trotter's method alone (O. H. Killen).

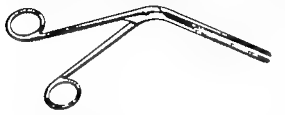


Fig. 1492.—Tilley's nasal forceps.

b *Packing the Nose.* By adopting Trotter's method the number of cases requiring packing are relatively few: 10 out of 80 cases in O. H. Killen's series.

A single length of 1 cm. wide selvedge-edged gauze saturated with B.I.P.P.[3] is used. The pack is inserted best with a nasal forceps (*Fig.* 1492), starting high posteriorly in the nasal passage. The packing is conducted so that layer upon layer is inserted, filling each recess between the conchæ and thereafter the vestibule, until the floor of the cavity is reached, when the proximal end of the gauze is left protruding from the anterior naris (*Fig.* 1493). Gauze impregnated with B.I.P.P. can be kept in longer than plain gauze as it does not become infected readily.

Usually the packs are removed in 24–48 hours, the nose being repacked if hæmorrhage recurs; nevertheless, some authorities leave the pack in place for much longer—even for so long as ten days. An antibiotic, usually penicillin, is administered for the whole of the period and for four or five days after the pack has been removed. When bleeding continues in spite of packing, as a rule repacking with the addition of a post-nasal pack is carried out in less than 24 hours.

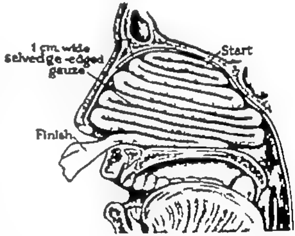


Fig. 1493.—Anterior nasal packing completed.

In the case of telangiectasia (Osler's disease), gauze packing should not be used, as it so frequently causes renewed hæmorrhage from trauma tiring the mucous membrane at the time or when the packing is removed. A finger-stall placed in the nasal cavity and then stuffed with gauze should be employed in these cases. Osler's disease is the only condition in which X-ray therapy for epistaxis may be useful. (*See also* Rex Blaubaum's Case, p. 1069.)

The Posterior Nasal Pack. Unless the bleeding point is in the nasopharynx, the post-nasal pack acts only as a bung. With the nose packed anteriorly and posteriorly blood may be forced into the nasal sinuses or along the Eustachian tube into the middle ear. Blood in the nasal sinuses is silent until it becomes infected, whereas a hæmotympanum, because of the pain it engenders, frequently calls for myringotomy. Blood can also be driven up the lacrimal duct into the conjunctival sac, with the disconcerting result that the patient weeps tears of blood.

[1] Roche Product, Ltd.
[2] Allen & Hanburys, Ltd.
[3] B.I.P.P. = Bismuth, Iodoform, Paraffin Paste.

In spite of these untoward possibilities, when persistent or recurrent bleeding is issuing from the posterior part of the nasal fossa some form of local pressure on the bleeding area becomes mandatory. Since the posterior nasal tampon described by J. K. M. Dickie of Ottawa, has been adopted at the Mayo Clinic, complications arising as a result of the pack, notably hæmotympanum, have become less frequent (O. E. Hallberg).

Technique. A piece of sterile gauze 3 in. (7·5 cm.) wide is folded lengthwise 1 in. (2·5 cm.) from the edge (*Fig.* 1494 A). It is then rolled until the thick end is a little less than ⅖ in. (1·0 cm.) and the excess is cut away. Around its middle is tied moderately tightly a long piece of strong silk. The ligature is then bound criss-cross around the thinner end, and tied extremely tightly. A No. 8 rubber catheter is passed through the bleeding passage to the throat, where the tip is grasped in a long hæmostat and drawn out of the mouth. One of the long ends of the silk is stitched or tied to near the extremity of the catheter. The catheter is withdrawn from the nose, together with the silk attached to it. In this way the pack, which has been moistened with liquid paraffin, is drawn against the

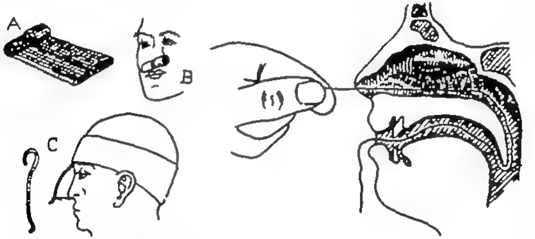


Fig. 1494.—The posterior nasal tampon in place. A, Folding the piece of gauze. B, Retaining the tampon by winding the string around a piece of rubber tubing. C, Alternative method. (*After J. K. M. Dickie.*)

posterior naris (*Fig.* 1494). The string issuing from the nose is threaded on a strong needle which is made to transfix a piece of half inch wide drainage tube. The string is then drawn through the tubing until the desired tension is reached, and the excess is wound around the tube (*Fig.* 1494 B). An even better method is to incorporate a coat hanger wire in a plaster-of-Paris cap around the head (*Fig.* 1494 C). The wire is bent a little, and then the string is wound a number of times around the tube before it is tied. In this way the correct tension can be adjusted with ease and maintained. Dickie leaves the pack in place for a week. On no account must the string issuing from the mouth be under tension, or it will cut into the soft palate. It remains dangling from the mouth, or fixed loosely to the cheek with strapping until it is required for withdrawing the tampon.

Alternative Procedures.

1. The bag of a Foley's catheter is inserted into the nasopharynx, and after the bag has been inflated, moderate tension is applied by strapping the shaft of the catheter to the cheek.

2. A rubber finger-stall is inserted along the floor of the nasal cavity with alligator forceps. Ribbon gauze is then packed firmly into its distal end, which, having been rendered bulbous, is kept in position by tying a ligature around the proximal end of the finger-stall and affixing the long ends of the ligature to the cheek.

Ligation of the External Carotid Artery is most likely to become necessary in older patients suffering from arteriosclerosis or hypertension, and particularly in cases where recurrent hæmorrhage is occurring from the posterior part of the nose. Ligation of the external carotid, in these circumstances, is a life-saving measure, and many cases have been reported where it has proved successful after other measures have failed.

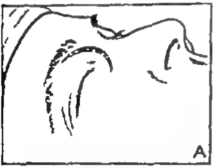
In coming to a decision whether or not to ligate the external carotid artery, the blood-pressure, the erythrocyte count, the availability of blood for transfusion, are all factors which must be taken into consideration. When daily transfusion of 1 to 3 pints

(0.5" to 1.7 L) of blood fails to raise the hæmoglobin above 60 per cent and to maintain a normal blood pressure, or when in spite of repeated packing and other intranasal treatment, profuse bleeding continues for more than three days, the operation should not be delayed.

Ligation of the External Carotid Artery.—For technique, see p. 833

Ligation of the Contralateral External Carotid Artery in addition.—When, as occasionally occurs, profuse bleeding recommences in spite of ipsilateral ligation of the external carotid artery,[1] there should be no hesitation in ligating the remaining one. A. Wolferman and F. J. Dwyer found it necessary to undertake bilateral ligation on six occasions in eight years. Prior to the second ligation some of the patients were almost moribund, but in all cases as a result of the second ligation the patient recovered. A smaller number of similar cases have been published by other authors. It should be noted that neither unilateral nor bilateral external carotid ligation causes any temporary or permanent inconvenience to the patient. It should also be noted that ligation of the external carotid should not be undertaken if the hæmorrhage is certainly or almost certainly occurring from high up in the anterior portion of the nasal fossa, for here bleeding is issuing from the anterior ethmoidal artery—a branch of the internal carotid artery.

Ligation of the Anterior Ethmoidal Artery.—Only occasionally is it necessary to resort to ligation of this vessel. One of the main indications is in a fracture of the anterior cranial fossa, where the crevice extends through the ethmoidal or the fronto-ethmoidal suture.



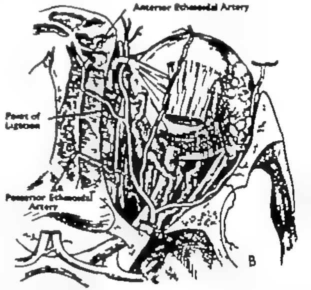


Fig. 1493.—A, Incision for exposure of the anterior ethmoidal artery. (*After G. Weddell.*) B, Showing the point at which the anterior ethmoidal artery is ligated.

Such a fracture is apt to tear the anterior ethmoidal artery in its bony canal, where the artery can neither retract nor contract. Sometimes bleeding comes on immediately, or, following infection, later. Another potent source of serious anterior ethmoidal hæmorrhage is a heavy blow on the nose where one or both ethmoid bones are fractured in addition to the nasal bones. Non-traumatic hæmorrhage from high in the anterior nasal fossa also occasionally calls for anterior ethmoidal artery ligation.

Operation.—The operation, which is not, as might be thought, particularly difficult, can be carried out under local anæsthesia with advantage. A curved incision is made commencing at the base of the inner third of the eyebrow and passing to the inner quarter of the lower rim of the orbit below (*Fig.* 1493 A). The incision passes down to bone; considerable, if not disconcerting, hæmorrhage ensues. After bleeding points have been ligated, the periosteum of the inner wall of the orbit, together with the lacrimal sac and the ligaments related to it, is elevated, the secret of success being to keep close to the bone. It should be noted that the artery is ligated *within the orbit*; if the periosteum is raised, the pulley of the superior oblique will not be jeopardized. Deepening the dissection and keeping close to the bony wall of the orbit, it will not be long before the anterior ethmoidal

[1] The only explanation for the continued hæmorrhage is that the bleeding vessel is fed by the external carotid of the opposite side. It appears that the collateral circulation is established immediately after the ligation of one carotid artery.

artery (*Fig* 1495 B) is encountered. To divide the artery between ligatures is extremely difficult and it should not be attempted. To occlude its lumen with a metal clip used in intracranial surgery is ideal, but in the absence of this equipment, to catch the vessel in a fine hæmostat and then contact the shaft of the hæmostat with a diathermy electrode will ensure that the vessel bleeds no more. The wound is sutured lightly, glove drainage being provided if there is oozing.

There are occasions when both the external carotid artery and the anterior ethmoidal artery require ligation, even on both sides.

Rex Blanbaum's Case.—A woman aged 60 years suffered from gross familial multiple telangiectasia of the cavernous type (Osler's disease) present on the face and the nasal mucosa. During the previous four years she had had several attacks of epistaxis requiring cauterization, packing, and blood transfusion. In all she had received 72 transfusions and several courses of deep X-ray therapy. On this occasion she was admitted blanched and shocked. After blood transfusion, Blanbaum ligated the external carotid artery and the anterior ethmoidal artery on one side, and a week later ligated the corresponding arteries on the contralateral side. No serious hæmorrhage recurred up to the time of the report, three years later.

In two cases described by H. Oppenheim and others, ligating the anterior ethmoidal artery proved life-saving when tying the external carotid artery had failed.

Fracture of the Nasal Bone.—(See p. 810.)

FOREIGN BODIES IN THE NOSE AND NASOPHARYNX

Usually the patient is a child or a mentally abnormal person. The common site for a foreign body to become impacted is between the septum and the middle concha (*Fig.* 1496). On rare occasions a foreign body entering the mouth becomes projected into the nasopharynx (*Fig.* 1497). Food may enter the nasopharynx and the nose during the act of vomiting.

Treatment.—

In children the safest procedure is the administration of an anæsthetic and the removal of the foreign body by means of a forceps or scoop.

In adults and older children the nose should be sprayed with a solution of equal parts of cocaine 10 per cent and adrenaline chloride 1–1000, and then under direct vision an

Fig. 1496.—Foreign body in the nose (a ring).

Fig. 1497.—Radiograph of safety-pin in the nasopharynx. Patient aged 8 weeks. (*F. Watson-Williams, Bristol Medico-Chirurgical Journal.*)

attempt should be made to remove the foreign body. If it is unsuccessful a general anæsthetic will be necessary. The most useful instruments for removing foreign bodies from the nose are a forceps with scoop ends, such as the smallest Luc's forceps (*Fig.* 1498), or Desjardin's gall-stone forceps. Long fine aural dressing forceps or a blunt hook may be of service.

A body far back in the inferior meatus may be pushed into the nasopharynx, where a finger awaits it and steadies it until seized with forceps introduced through the mouth. In doing this, first extend the head over a pillow so that the foreign body does not slip

down the pharynx before it can be secured. A foreign body in the nasopharynx is usually delivered most easily through the mouth. Such bodies as safety pins are, however, often impacted with the point downward (see *Fig.* 1497) and if there is any difficulty in securing the point, the object is best delivered through the nostril; to allow the point to penetrate the wall of the pharynx is to incur a serious risk.

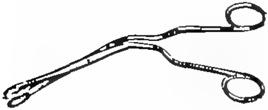


Fig. 1498.—Luc's forceps.

Maggots in the Nose.—In warm climates it is not uncommon for the eggs of the house-fly, saw-fly, or the bluebottle to deposit their eggs within the nasal cavity; usually the eggs hatch within 24 hours.

The symptoms are those of acute sinusitis. There is a purulent nasal discharge, often with odour. The maggots cling to the tissues with great tenacity, and if not removed quickly will denude the bone and cartilage; even the cranial cavity has been invaded, with fatal results. The diagnosis is made by finding maggots or eggs in the nasal secretions or within the nasal cavity.

Treatment.—The most effective remedy is to stupefy the maggots by chloroform vapour and dislodge them by syringing with a very weak solution of carbolic acid.

THE ACCESSORY NASAL SINUSES

ACUTE FRONTAL SINUSITIS

The majority of sufferers from acute frontal sinusitis are under 21 years of age, and fulminating cases are more frequent below the age of 15 years (W. J. McNalley and E. R. Stuart). Antibiotics do not appear to have reduced the incidence of this disease. In the course of a heavy cold the patient develops malaise, some elevation of temperature and pain located over the involved sinus. It is the latter symptom that compels him to seek advice. Diving, and especially plunging into water from a height feet first, are also well-known causes of acute frontal sinusitis.

Usually the pain commences one or two hours after rising, increases in severity towards noon, and diminishes in the middle of the afternoon; sometimes it radiates to the temporal area. Early in the course of the disease the mucous membrane lining the sinus becomes œdematous, and partial obstruction

Fig. 1499. Increased density of the shadow of the left frontal sinus.

Fig. 1500.—Œdema of the eyelid secondary to left-sided acute and ethmoidal frontal sinusitis. (*Mr. F. Bauer, Liverpool.*)

of the fronto-nasal duct results. Examination reveals tenderness over the floor of the frontal sinus, and frequently percussion elicits pain over the anterior wall.

Examination of the Interior of the Nose.—If the natural ostium is not blocked, pus will be seen exuding over the front of the inferior concha.

Radiography is most helpful, and if possible should be carried out in every case. Not only is valuable information given as to the size and shape of the sinus, but sometimes opacity (*Fig.* 1499), or the presence of a fluid level is demonstrated.

So long as drainage can occur along the duct the symptoms remain comparatively mild should drainage cease often a rapid progressive *fulminating inflammation sets in* and is heralded by an exacerbation of the general symptoms and signs of œdema with perhaps redness of the eyelids (*Fig* 1300) *Unless drainage is established serious complica*tions follow These include orbital cellulitis or orbital abscess (*see* p 1040) osteomyelitis of the frontal bone (*see* p. 1072) epidural abscess subdural abscess, meningitis, brain abscess, and sagittal sinus thrombosis which are described in Chapter LXX A combination of acute frontal sinusitis and acute ethmoiditis (*see* p. 1072) is common

Conservative Treatment.—Penicillin and streptomycin or a broad-spectrum antibiotic, is given while awaiting the result of cultures and sensitivity tests. The antibiotic selected should be *continued for seven days after complete remission of symptoms*. Codeine and aspirin *usually control the pain* *Pledgets of cotton wool soaked in 25 per cent argyrol* placed in the middle meatus, and left there for half an hour will promote shrinkage of the mucous membrane Such local treatment should be followed by suction. These measures are preferable to the application of a vasoconstrictor drug which is *so liable to be followed* by vasodilatation Sometimes moist warm compresses applied over the involved sinus prove comforting

When the frontonasal duct is completely obstructed external drainage of the frontal sinus should not be delayed. The operation is called for rarely except in cases of an acute exacerbation of chronic sinusitis.

External Drainage of the Frontal Sinus.—General or local anæsthesia can be employed Local infiltration with 1 per cent procaine and *adrenaline* 1–50,000 is used in either instance, and is effective in minimizing bleeding With adequate pre-operative sedation, local

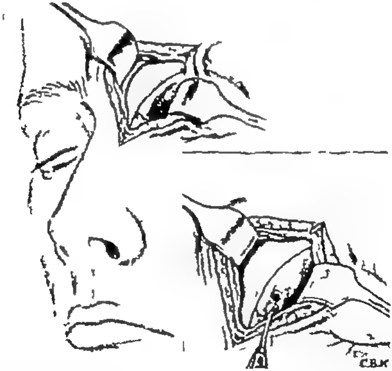


Fig. 1301 —The floor of the frontal sinus has been exposed by elevating the periosteum covering it. *Inset* *The floor of the sinus has been drilled, the hole being large enough to* accommodate a No. 14 French catheter

anæsthesia is preferable. The eyebrow is not shaved. The incision is commenced at a point mid-way between the inner canthus and the dorsum of the nose, and is carried laterally just below the eyebrow for a distance of 2 or 3 cm The incision is made down to the periosteum, and *after hæmorrhage from the angular venous plexus* has been controlled the periosteum is incised throughout the length of the incision The supra-orbital ridge is identified along its *inner half* and a periosteal elevator is used to elevate the periosteum from the roof of the orbit Small retractors will expose the denuded bone (*Fig* 1301) with only

slight displacement of the globe. The next step is to enter the frontal sinus through the thin plate of bone that forms its floor.

The best instrument for this purpose is a dental burr, which can often be procured by arrangement with a dental surgeon. In the absence of this apparatus the smallest cranial burr can be employed. The opening in the bone should be no larger than will accommodate a No. 14 F. catheter. In most instances, as soon as the sinus is entered pus will flow under pressure. No suction is employed in the sinus lest part of the interior be denuded of its mucosa. The use of a probe or a curette is forbidden. No attempt is made to enlarge the opening sufficiently to inspect the interior of the sinus. The sole object is to establish drainage by means of a medium-sized catheter. Multiple sutures are unnecessary; only one suture is placed at each end of the wound, and one to anchor the tube. A light dressing is applied without pressure. No attempt is made to irrigate the sinus. As a rule the tube is removed on the fourth or fifth day. The deformity following this trephine operation is practically nil. The antibiotic therapy preceding the operation is continued for 10 to 14 days thereafter. In a consecutive series of 14 patients operated upon by this technique, H. J. Ronis had to reinsert the catheter in one case only, and that for a matter of three further days. The end result in all patients was good with the continued use of antibiotics and antihistaminics over prolonged periods. In the rare event of bilateral infection of the frontal sinuses requiring external drainage, a "spectacles" incision can be employed.

OSTEOMYELITIS OF THE FRONTAL BONE

Osteomyelitis of the frontal bone commences about 10 days after the onset of imperfectly treated acute frontal sinusitis. Since a direct communication exists between the veins of the upper part of the mucosal lining of the frontal sinus with those of the diploë of the frontal bone, the reason for the involvement of the latter is not obscure. Osteomyelitis is characterized by considerable pyrexia, severe pain, tenderness, usually the development of swelling over the frontal bone and pitting œdema of the scalp over the site of the disease (Pott's puffy tumour). The classical swelling and pitting œdema are not always present. As elsewhere, radiographs are of no help in detecting early osteomyelitis.

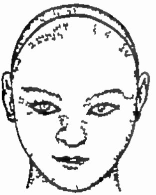


Fig. 1302.—Incision for displaying the frontal bones. Note that this incision is entirely within the hair line.

Antibiotic Treatment.—In very early *acute* cases, provided drainage of the affected sinus is free, antibiotics may obviate the necessity for operation. In *subacute* cases the chances of a cure resulting from antibiotic therapy alone are much less. When bone infection has been present for some days before it is detected, while temporary respite is obtained with antibiotic therapy, the chances of smouldering foci lighting up are too great to justify temporizing.

Operation.—A coronal incision is made in the hair line extending from the top of one ear to a similar point on the opposite side (*Fig.* 1302). The periosteum is elevated anteriorly and a scalp flap is brought down over the face. All soft necrotic bone must be removed and not infrequently this exposes an epidural abscess. It is essential to excise all diseased tissue even down to the ethmoids. This completed, the flap is replaced and sutured into position with glove drainage at the most dependent points.

ACUTE SUPPURATIVE ETHMOIDITIS

Acute suppurative ethmoiditis is comparatively rare. Sinusitis in infants and young children is largely confined to the ethmoid, as it is the only sinus that is well developed early in life. As a rule one of the acute infectious diseases, such as scarlet fever or measles, precedes its onset. The constitutional symptoms are slight pyrexia, sometimes accompanied by mild toxæmia. The symptoms include headache with neuralgic pains radiating to the back of the eye. Unilateral nasal obstruction with anosmia is present, as also is tenderness over the globe.

Conservative Treatment.—Antibiotic therapy, together with the local application of heat, preferably with an infra-red lamp, often proves effective. Tampons of 10 per cent argyrol in the middle meatus, left in place for 10 to 20 minutes, promote drainage

External Drainage of the Ethmoidal Sinuses.—

The Incision.—As in this condition it is usual for the frontal sinus to be infected as well, the steps of the operation are similar to those already described, with the following additions. The skin incision is carried a little lower down to the frontal process of the maxilla, as is shown in Fig. 1329 A. The steps of exposure and ligation of the anterior ethmoidal artery are precisely those described under ligation of that vessel (p. 1068).

Exposing and Entering the Sinus.—The mesial orbital wall, formed by the lacrimal bone and the lamina papyracea behind it, is now clearly in view. As a rule some portion of the wall will be seen to be obviously diseased. If this is not the case, a small, sharp spoon is pressed against the posterior end of the lacrimal bone, which yields readily, opening the ethmoidal labyrinth. The infected air-cells are removed with the spoon and Luc's forceps, punch forceps being employed to enlarge the opening, as necessary.

ACUTE MAXILLARY SINUSITIS

As the maxillary antrum does not attain full development until the twelfth year, serious infections of this cavity are more likely to occur in patients past that age. Like frontal sinusitis, the most usual precursor is the common cold, but less frequently (but more resistant to conservative measures) are infections due to extension from an apical dental abscess or as the result of perforation of the floor of the antrum during extraction of an infected tooth. The teeth most commonly associated with either of these contingencies are the first, third and second molar, and the premolars, in that order.

Diagnosis.—The constitutional symptoms are often severe, especially when the pus is confined by occlusion of the natural ostium. Pain in the cheek and the upper teeth, dull throbbing when the patient stoops, is characteristic. It is not so severe as the pain of frontal sinusitis, but it is more constant. Commonly the patient considers that the pain is due to toothache, and visits a dental surgeon. Frequently the affected side of the face is swollen and the lower eyelid is somewhat œdematous. Breathing through the nostril on the side of the lesion is impaired, and often obstructed completely. Not until the third or fourth day of the attack is a unilateral purulent discharge much in evidence. Local tenderness over the antrum is a less reliable sign than in the case of frontal sinusitis. Both transillumination of the antrum and a radiograph of the region (*Fig.* 1503) are likely to reveal relative opacity of the affected antrum. In cases of real doubt the diagnosis can be confirmed or disproved by puncturing the antrum with a hollow needle (see below).

Fig. 1503.—Considerable increase of the density of the shadow of the left maxillary sinus.

Treatment.—Drainage of the maxillary antrum is impeded by the position of its ostium high on the medial wall. Therefore, except in very early and comparatively mild cases, antibiotic therapy alone cannot be expected to bring about resolution. On the other hand, antibiotic therapy plus irrigation of the antrum, repeated as necessary at intervals of three or four days, brings about a cure in over 90 per cent of cases.

Puncture and Irrigation of the Maxillary Antrum.—The patient should be seated bolt upright with a nurse so steadying his head that he cannot extend it. The most satisfactory method of performing puncture of the maxillary antrum is by means of an 18-gauge ordinary 3½ in. lumbar puncture needle, after surface anæsthesia has been obtained high beneath the inferior concha with a tampon soaked in 4 per cent xylocaine-adrenaline solution. It is also necessary to apply a similar pack beneath the middle concha, to promote patency of the ostium. With the bevel of the needle directed laterally, to prevent the point slipping along the wall, the point of the needle is passed beneath the inferior concha in an upward, backward, and outward direction until the point impinges on the bony wall. Moderate pressure of the thumb (*Fig.* 1504) will enable this thin wall to be penetrated easily. The procedure is painless, and when the needle has been inserted into the cavity, approximately 1-1½ in. (2.5-3.8 cm.) of the shaft, including the base, remains protruding from the naris (*Fig.* 1505). The stylet is removed, and by aspiration with the syringe or, if necessary, by aspiration after a small quantity of sterile saline solution has been injected, a specimen for bacteriological examination is obtained. With the head tilted slightly forwards, sterile

normal saline solution is injected with a larger syringe the overflow running into a kidney-dish which the patient holds. W. T. K. Bryan much prefers Ringer's solution for this purpose as he claims it does less damage to the already damaged mucous membrane than normal saline solution. The injection is repeated until the solution is returned clear. Attention has been drawn to the danger of air embolism while irrigation of the antrum is in progress (see p. 107) and the surgeon must be vigilant that no air is injected along with the chosen irrigating solution. Usually the sinus is free from pus at the end of the second or third

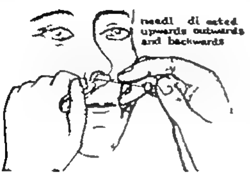


Fig 1504.—Method of inserting the needle to the maxillary antrum.

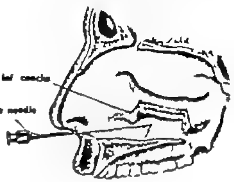


Fig. 1505.—Puncture of the maxillary antrum completed (J. A. B. Hall.)

treatment by puncture and irrigation. An aqueous suspension of penicillin C procaine 600,000 units in 2 ml. of sterile water can be instilled into the cavity with advantage (J. Elsen).

From what has been stated already it will be appreciated that the indications for open drainage of the maxillary antrum are few and are confined practically to cases of severe infection of dental origin that do not respond quickly to the above measures, and when a detached root of a tooth has been driven into the antrum.

The Caldwell Luc Operation.—Endotracheal anesthesia is advisable for it allows the post nasal space to be packed such packing is usually carried out by the anesthetist.

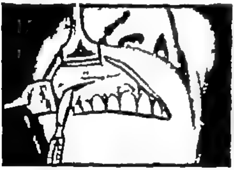


Fig 1506.—The Caldwell-Luc operation. Making the incision

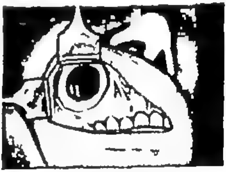


Fig 1507.—The Caldwell-Luc operation completed

One per cent novutox or procaine-adrenaline solution, injected beneath the mucoperiosteum of the canine fossa with a dental syringe will diminish subsequent bleeding.

An incision is made with a tenotomy knife in the sulcus between the gums and the cheek above the bicuspid and first molar teeth (*Fig* 1506). Employing a periosteal elevator the anterior wall of the antrum is exposed to within a finger breadth of the infra orbital foramen. The wall of the antrum is opened with a small gouge and hammer. The resulting hole (*Fig* 1507) is enlarged by nibbling forceps, sufficiently to display the whole of the interior of the antrum. Pus is evacuated. Should the mucosa lining the canine fossa be intact it is removed over the area denuded of bone. The interior of the antrum is lightly packed with gauze soaked in hydrogen peroxide for a few minutes, which allays oozing. The pack is then removed, and the interior is inspected. As a rule in acute cases no attempt is

made to remove the lining from the rest of the cavity. Should the antrum be filled with polypi as it might be in a case of acute-on-chronic sinusitis, it is probably advisable to elevate the mucous membrane with a Watson Cheyne dissector and remove the diseased, polypi bearing mucosa with Luc's forceps. According to the classical Caldwell Luc operation a quadrilateral piece of bone $\frac{1}{4} \times \frac{3}{4}$ in. (6×18 mm.) is now removed from the lateral nasal wall corresponding to the inferior nasal meatus without injuring the nasal mucous membrane. The latter is then cut as a window with the base level with the floor of the nose and allowed to lie on the floor of the antrum, a step that is not always possible, particularly in cases operated upon previously.

Drainage of the maxillary antrum into the nasal cavity is unnecessary for removal of a root of a tooth pushed into the antrum, but in the treatment of acute-on-chronic maxillary sinusitis that develops only when the internal ostium is blocked by polypi or adhesions intranasal drainage is essential. The mucoperiosteal incision in the canine fossa should be repaired by two or three catgut sutures. Omitting this step favours the development of an oro-antral fistula. Unless there is troublesome oozing the antrum is not packed. Most surgeons deprecate post-operative lavage of the sinus.

ORO-ANTRAL FISTULA

Traumatic oro-antral fistula of dental origin has become a common clinical entity owing, mainly, to the use of fine apical elevators in difficult extraction of teeth in relation to the antrum. When a small plate of compact bone is seen attached to an apex of a root of an extracted tooth that was in relation to the antrum, an oro-antral fistula should be suspected. Actually the mucosa is sometimes intact, but on blowing the nose a few days later the mucosa gives way and a fistula results. For this reason in relevant cases the patient should be warned not to suck the tooth socket or blow his nose for a week. In doubtful cases injection of a radio-opaque medium and radiographs will confirm the presence or absence of fistula.

Treatment.—The immediate treatment of an oro-antral fistula is as follows: removing some of the alveolus, if necessary, sutures are tied across the gums anteriorly and posteriorly. A third suture is inserted across the middle of the socket, taking a deep bite of the tissue. A strip of ribbon gauze, moistened with acriflavine solution, is then packed lightly into the socket and the suture tied over it (*Fig.* 1308). It should be noted that the ribbon gauze is

Fig. 1308.—Temporary closure of a traumatic oro-antral fistula. (*After* B. W. *Fickling.*)

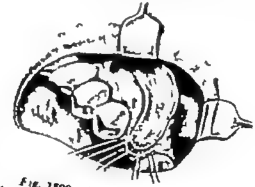


Fig. 1309.—The mucoperiosteal flap operation for closing an oro-antral fistula. (*After* B. W. *Fickling.*)

used as a cover and not as a pack. If the patient wears a denture, so much the better. It can be used to protect the area. The gauze is removed on the third to the fifth day and the sutures on the fifth or the seventh day. Unless the antrum has become shut off as the result of the temporary occlusion of the fistula, a more effective closure must be undertaken.

Patients seen first with gross sinusitis are given an antibiotic parenterally, and the sinus is irrigated daily through the fistula. When the infection has abated, the sinus should be irrigated occasionally for six weeks, after which the fistula must be closed by a flap of mucoperiosteum, as shown in *Fig.* 1309. It is especially important that the base of the periosteum, and the periosteum only, be transected, so as to allow the flap to be slid sufficiently

to cover the defect without tension. Should the patient be seen within thirty-six hours of the accident B W Fickling recommends that the slide operation should be performed as a primary procedure

THE PHARYNX

HÆMORRHAGE AFTER TONSILLECTOMY

The volume of blood that can be lost by a patient in fairly good general condition without serious consequences varies with the patient's age and is equivalent to one tenth *of the total blood volume . So it comes about that in a child aged 2 years the loss of a* teacupful (100 ml.) results in anoxia. Owing to the oligæmia cyanosis is unlikely to be evident and the only sign of anoxia is restlessness. Heavy sedation (for restlessness), further anæsthesia (to arrest the hæmorrhage) and possibly more (post-operative) sedation, without adequate blood replacement is the most frequent cause of death in cases of serious hæmorrhage following tonsillectomy Therefore (*a*) When matched blood cannot be *procured quickly enough to supplement the falling blood volume intravenous dextran should* be given (*b*) The amount of sedation must be kept at the lowest level compatible with tranquillity as opposed to semi-consciousness and (*c*) Sedation following a second anæsthetic is best confined to Mist L.P.C.

Blood-supply of the Tonsil.—*Arterial* —While as can be seen from *Fig* 1510 several named branches of the external carotid artery give twigs to the tonsil, the largest of these is one from the facial artery situated at the lower pole of the tonsil, close to the tongue Like

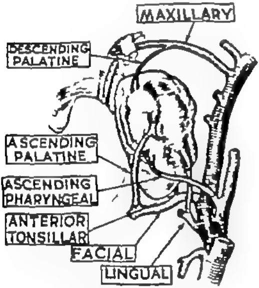


Fig 1510.—The arterial supply of the tonsil. (*After R H Fowler*)

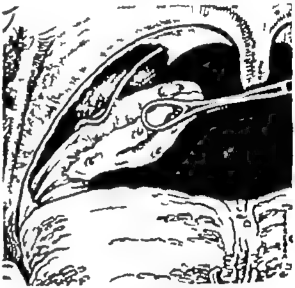


Fig. 1511 —The paratonsillar vein. (*Mr Denis Browne*)

all arteries about this size after division the tonsillar arteries soon cease to bleed owing to contraction of their walls, unless they are atheromatous.

Venous —There is a vein unaccompanied by an artery in the tonsillar bed—the paratonsillar vein (*Fig* 1511). Like other unaccompanied veins, it varies in size and may be double or treble (Denis Browne). When divided, the bleeding end retracts into the upper corner of the tonsillar fossa. Should the intravenous pressure rise (from respiratory obstruction) the lower distal end will bleed. Perhaps the most serious bleeding from this vein is due to its wall having been button-holed but not divided completely It is alleged that in the majority of cases serious hæmorrhage after tonsillectomy is venous. This would account for the fact that ligation of the external carotid artery is so often ineffectual in controlling tonsillar hæmorrhage

Classification of the Bleeding.—Hæmorrhage is more profuse during the guillotine operation than during the dissection operation, and a certain amount of bleeding is to be *expected during the first hour following tonsillectomy* by either method. Surprising to relate from his experiences at the Birmingham Children's Hospital, Stirk Adams found

that the risk of alarming post-operative hæmorrhage after the dissecting operation was three times greater than after the guillotine operation.

Hæmorrhage following tonsillectomy falls under one of three categories —

1 *Reactionary Hæmorrhage*—that occurring within the first twenty four hours after operation.

2. *Hæmorrhage during Convalescence*—that occurring most commonly on the fifth night or the sixth day *following operation. This variety of hæmorrhage is associated with separa*tion of the primary clot from the tonsillar bed, and also possibly the separation of ligatures if these have been used (D W Ashcroft)

3. *True Secondary Hæmorrhage* occurs most often on the eighth post-operative day but sometimes is *delayed until one of the succeeding four or five days. This form of hæmorrhage is associated with damage to the muscular tissue of the tonsillar bed* and is due to sepsis and often necrosis, which results in sloughing of the wall of a blood vessel.

MANAGEMENT OF A CASE OF HÆMORRHAGE FOLLOWING TONSILLECTOMY

Oozing more evident after the guillotine operation than after dissection of the tonsils, is to be expected *during the first hour following tonsillectomy In order to minimize swallow*ing of blood, the patient is placed in the left lateral position with the foot of the bed raised.

1 Reactionary Hæmorrhage.—When oozing occurs after the first hour or should vomiting of fresh blood occur the patient must be deemed to be suffering from reactionary hæmorrhage *If a post-operative sedative has not been given already it must be administered forthwith—for an adult morphine ¼ gr (16 mg) subcutaneously* for a child, nepenthe *in an amount commensurate with the patient's age (i.e 1 minim for each year of the child + 1).* Unless the hæmorrhage is so alarming as to merit immediate attention it is advisable to wait 20 *min. for the drug to take effect when, as a result of diminished throat reflexes* and allied nervous tension examination of the tonsillar bed can be accomplished effectively It should be *an invariable rule to make the examination even if the patient* (as a result of the morphine) has to be awakened from sleep.

EXAMINATION OF THE TONSILLAR BED.—

Armamentarium—Adequate illumination must be obtained. A number of suitable swabs are prepared by rolling cotton wool into a hard ball, and covering each ball with a layer of gauze, which is kept in place by a ligature or stitch. When they are to be used the swabs are grasped in swab-holding forceps. A mouth gag a tongue depressor three long hæmostats, Luc's forceps, and a long dissecting forceps also are placed upon the tray A gallipot for the reception of the operator's choice of styptic—hydrogen peroxide or stypven —for oozing thrombin topical or pure turpentine for bleeding are a usual choice.

Seeking the Bleeding Point—The patient should be seated in an upright position, and if necessary supported in this position by a nurse. If old enough, he is given a tumblerful of cold water and is asked to rinse out his mouth three or four times, and to eject the rinsings into a kidney-dish. A final mouthful is then taken, and swallowed. If there is no bleeding to be seen, no further action is taken for the time being When there is bleeding the tongue is depressed gently but firmly by means of a tongue depressor held in one hand, and with Luc's forceps, or failing that instrument, a long hæmostat *every particle of clot must be removed*, in order to allow the musculature of the tonsillar fossa to contract. In this respect the tonsillar fossa may be likened to the uterus (A. Lee McGregor).

Applying Compression to the Tonsillar Bed—Pressure is applied to the bleeding area in the tonsillar bed with a swab on a holder which is removed after a few minutes and replaced by another the swab of which has been moistened with the chosen styptic. Firm pressure must be continued for 10 to 15 min., combined with gentle counter pressure from outside beneath the angle of the mandible. These measures, carried out as detailed will, in the majority of cases, cause reactionary hæmorrhage to cease.

ON MAKING ARRANGEMENTS FOR BLOOD TRANSFUSION.—Cross-matching should be carried out early so that *if the blood loss is deemed sufficient to merit blood transfusion*, it can be carried out as soon as compatible blood is forthcoming At the Birmingham Children's Hospital it has been found that 6 oz. (180 ml) of whole blood is the most effective measure in the control of hæmorrhage that *fails to cease soon after the above measures* have been applied.

MORE SERIOUS HÆMORRHAGE.—When it is obvious that a *comparatively large artery* is involved, or when bleeding continues in spite of the measures detailed above or more

rarely still, when trismus prevents efficient compression, the patient must be taken to the operating theatre. While on his way thither his head must be kept strictly on one side, the bleeding side lowermost, with a swab on a holder compressing the tonsillar bed. Usually it is advisable to start a blood transfusion, or failing that a plasma or dextran infusion, before seeking the bleeding point. When all is in readiness, a small dose of thiopentone can be injected into the tubing of the transfusion apparatus. Before administering the thiopentone the patient should be placed in a head-down position to help to prevent blood entering the air passages. It is most desirable to employ endotracheal anæsthesia with a cuffed tube. In the absence of these facilities one must rely on the tonsillar position, viz., the head held in an extended position unsupported by the leaf of the operating table which is lowered. This will prevent blood entering the air passages; also this is the position *par excellence* for effecting hæmostasis in the tonsillar bed. Having inserted a suitable mouth-gag and drawn the tongue forwards, the tonsillar bed is inspected in a good light, and if a bleeding point can be seen it is seized in a long hæmostat. It is then under run with a ligature on a needle or, if available, Irwin Moore's needle (*Fig.* 1312) can be employed for this purpose.

Fig. 1312.—Irwin Moore tonsil suture needle.

When an obvious bleeding point cannot be found, the pillars of the fauces should be sewn together. A small piece of oxycel is placed in the cavity and stitches are inserted, as shown in *Fig.* 1313, care being taken to include muscle with each stitch. The stitches are removed after three days, and the remnants of the oxycel are allowed to become dislodged naturally.

In exceptional cases of definite arterial hæmorrhage it may be necessary to ligate the external carotid artery between the superior thyroid and the lingual arteries (*see* p. 853).

2. Hæmorrhage During Convalescence.—Bleeding of the delayed type, occurring nearly always on the fifth night following operation is, as a rule, not severe. Usually it ceases after a gargle of weak hydrogen-peroxide solution. Sometimes the hæmorrhage is associated with the presence of a piece of semi-detached clot that requires removal. Seldom is it necessary to transfer the patient to the operating theatre for this type of hæmorrhage.

3. True Secondary Hæmorrhage, which occurs about the eighth day after operation, is much more serious than the foregoing; fortunately it is also less common. As a rule there are small warning hæmorrhages, followed within twenty-four hours by a larger one. Amidst the sloughing œdematous tissue that constitutes the bed of the tonsillar fossa it is difficult, and usually impossible, to secure a single bleeding point. Musgrave Woodman taught that the best method of treating secondary hæmorrhage was to apply pure carbolic acid to the tonsillar bed without disturbing blood-clot. This he did on the initial sign of secondary *hæmorrhage occurring at any time after* twenty-four hours from the time of operation. Carbolic acid is a local anæsthetic, a local antiseptic, and in his experience its use always led to the cessation of this type of hæmorrhage. Should, however, a spurting hæmorrhage be seen it would appear that this is an occasion on which to ligate the external carotid artery without delay.

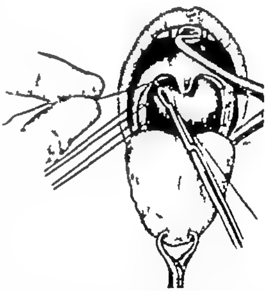


Fig. 1313.—*Suturing together the pillars of the fauces.*

HÆMORRHAGE FOLLOWING REMOVAL OF ADENOIDS

The bleeding area should be examined, if possible visually, or digitally, for a tag of adenoid tissue. If such a tag is present, its removal with Luc's forceps will often result

the hæmorrhage ceasing. Should the bleeding persist, the nasopharynx must be plugged in the manner described on p. 1060. In no case should the packing be left in place for more than 12 hours, otherwise serious infection of both middle ears via the Eustachian tubes will assuredly follow.

PERITONSILLAR ABSCESS

There are two varieties of peritonsillar abscess: (a) Anterosuperior, which is common; and (b) Posterior, which is comparatively rare.

Peritonsillar abscess is a complication of tonsillitis, but a relatively rare one. The condition commences as *peritonsillitis*. *In the common anterior variety, almost certainly* the infection of the peritonsillar tissue arises in one of the superior crypts which are *slit like*, deep and impinge on the capsule of the tonsil. Pus unable to escape through the mouth of the crypt erodes the capsule and escapes into the superior part of the space lying between the capsule and the superior constrictor (see *Fig.* 1516). Thus the tonsil is displaced downwards and towards the middle line (see *Fig.* 1514).

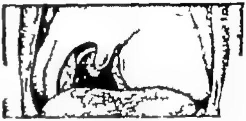


Fig. 1514.—The usual (anterosuperior) variety of peritonsillar abscess.

Bacteriological examination shows the infection to be a mixed one. *M. catarrhalis* is often the predominating organism.

Peritonsillar abscess occurs most frequently between the ages of 15 and 40; although it is not commonly encountered in children it is by no means a curiosity between the ages of 2½ and 15 years.

Diagnosis.—It is important to know that while the temperature is frequently 103° F. (39·4° C.) during the early stages of acute tonsillitis, by the time the pus has burst into the peritonsillar space rarely does the temperature exceed 100° F. (37·8° C.); frequently it is not more than 99° F. (37·2° C.). As the tension within the abscess increases, so does the pain. The *muscles of mastication pass into spasm*, and the patient cannot open his mouth sufficiently to permit a full examination of the throat. Swallowing is so painful that saliva dribbles from the mouth. This, *combined with inability to turn the head without increasing* the pain, is highly characteristic of the presence of a peritonsillar *abscess* as opposed to peritonsillitis. *When breathing becomes difficult and attacks of dyspnœa* awaken the sleeping patient, opening the abscess has been already delayed too long.

The use of a *suction appliance is helpful in aiding visual examination.* Swelling involving the soft palate and displacing the uvula towards the opposite side (*Fig.* 1514) is highly characteristic. When the abscess is ripe, digital examination will reveal softening of the centre of the swelling.

Treatment of the Stage of Peritonsillitis *is conservative. Confinement to bed, splinting* the neck by bandaging over wool, nursing in the sitting posture with pillows on each side of the head, are fundamental principles. Hot alkaline mouth washes will help to dissolve the thick glairy saliva so painful to dispel. Constipation must be avoided. The antibiotics of choice should have been determined as a result of swab culture with sensitivity tests. While awaiting the report, penicillin and streptomycin, or a broad-spectrum antibiotic, should be administered. By the early use of antibiotics before actual formation of pus, it is possible for resolution to occur. Once an abscess has formed, operation is imperative.

Opening the Abscess.—

Preparation.—Forty five minutes before the operation morphine, ¼ gr. (16 mg.) is given.

Anæsthesia.—The injection of local anæsthetic should be condemned. It is liable to break down barriers of resistance to infection, and to devitalize tissues. Except in very young children, general anæsthesia is unjustifiable: breathing is endangered during the stage of induction, and intubation may prove to be impractical.

Armamentarium.—On the right hand side of the operator there should be a tray on which has been placed:—

1. A gallipot containing a few drops of pure carbolic acid.
2. A sterile wooden applicator with flecks of cotton wool wound firmly on both ends.
3. A thin spatula or a dessertspoon, the handle of which makes an excellent tongue depressor.

4 A scalpel with a sharp, but short pointed blade e.g., Bard Parker No. 15 (*Fig* 1515 A). Failing that an ordinary pointed scalpel can be prepared as shown in *Fig* 1515 B.

5 Long sinus forceps.

The patient is propped up on a bed rest the light should come from over the operator's shoulder The patient is asked to swallow and open his mouth as best he can. Saliva is sucked from the base of the tongue One end of the applicator dipped in carbolic acid is applied to the mucous membrane of the soft palate for a few seconds. Should any of the

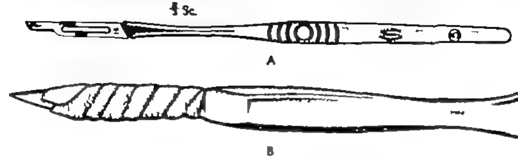


Fig 1515.—A, Bard Parker pattern scalpel No. 15 B, Method of winding adhesive plaster so as to render an ordinary pointed scalpel guarded.

acid trickle down, it must be swabbed away promptly with the dry end of the applicator The painted tissues become blanched. The whole procedure is repeated. The patient is then told he can close his mouth, and swallow [1] After about a minute the mouth is again opened and a spatula inserted. The area is sucked dry The point of the scalpel is stabbed firmly through the blanched area to the depth of 1 cm making a short vertical incision from the point depicted in *Fig* 1516 There should be gush of pus and a little blood. The patient leans forward, spits out the discharge, and rinses the mouth. Usually the opening is widened by sinus forceps—a procedure that is not resented by the patient. Such enlargement of the incision is imperative if pus does not flow Once the contents of the abscess have been evacuated, relief is immediate and almost always convalescence is rapid.

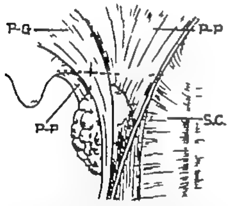


Fig 1516.—The musculature of the peritonsillar bed and the imaginary intersecting lines that give the optimum point for opening a peritonsillar abscess. P-G Palato-glossus P-P Palatopharyngeus; SC, Superior constrictor

Following a peritonsillar abscess the tonsil is so damaged that it is vulnerable to further peritonsillar abscess. In due course and after necessary dental treatment tonsillectomy should be performed.

Peritonsillar Abscess in Children.—In countries where diphtheria is rife the patient is often regarded as suffering from diphtheria. In view of the fact that the child presents symptoms of respiratory obstruction often with rib retraction, together with an inability of the examiner to obtain a good view of the pharynx because of trismus, this mistake is understandable.

Treatment —A general anæsthetic is to be preferred if circumstances permit. There is little danger of inhalation of blood or pus if the operation is carried out with the head and neck extended over a sandbag placed beneath the shoulders, and use is made of an efficient mouth-gag and a suction apparatus If possible two suction apparatuses are employed for rapid evacuation of pus. Danger is lessened still further if the depth of anæsthesia is such that the cough reflexes are just returning at the time of the incision.

Posterior Peritonsillar Abscess.—Pain nearly always radiates to the ear of the involved side There is but little swelling of the soft palate and the uvula. Posterior peritonsillar abscess tend to push the tonsil forward and a view of the swelling it engenders is at least

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[1] Some surgeons make it their practice to aspirate before draining the abscess. Aspiration confirms the presence of pus before making the incision, and has much to commend it

partially hidden thereby A century ago Trousseau pronounced that a peritonsillar abscess was almost never fatal He referred no doubt to the common anterior variety of peritonsillar abscess the *posterior variety unless dealt with promptly and efficiently often* gives rise to a parapharyngeal abscess which is an extremely dangerous condition.

Parapharyngeal Abscess is dealt with fully on p 848 under the title INFECTION OF THE PHARYNGO-MAXILLARY SPACE.

ACUTE RETROPHARYNGEAL ABSCESS

Acute retropharyngeal abscess in infants is caused by suppuration of one or more of the lymph-nodes of Henle which are situated in the retropharyngeal fascial space between the constrictor muscle of the pharynx in front and prevertebral fascia behind. The space is divided in the midline into two compartments by the buccopharyngeal fascia, which binds the back of the pharynx firmly to the prevertebral fascia. Hence an abscess in this situation is always to one side of the middle line and never central in position This feature helps to differentiate acute from chronic retropharyngeal abscess,[1] *the latter being situated behind* the prevertebral fascia. It is possible that in older children and adults acute retropharyngeal abscess is caused by perforation of the space by a foreign body such as a fish bone but more *frequently it is a complication of otitis media and mastoiditis. The ear as a primary focus,* warrants investigation in every case of retropharyngeal abscess.

Age Incidence.—In older children the retropharyngeal lymph-nodes have usually disappeared consequently acute retropharyngeal abscess is mainly a disease of infancy 88 per cent of all cases occurring during the first year of life *Contrary to statements in* many standard works, M. Davidson has found by a study of reported cases as well as a result of his own experience that acute retropharyngeal abscess in adults is not by any means the almost unheard of condition it is alleged to be

Bacteriological Investigations have shown the infection to be due to mixed flora in the majority of cases, but hemolytic streptococci usually predominate When pure cultures are obtained again they are of a hemolytic streptococcus.

Diagnosis.—The collection of pus behind the pharynx interferes with deglutition and respiration. If the apex of the abscess is situated in a nasopharynx, interference with nasal respiration results, and frequently it is thought that the patient is suffering from adenoids. When the apex is opposite the glottis, interference with deglutition and respiration is more exaggerated and, in order to maintain an adequate airway the child holds its head in full extension with the mouth open—a position considered by many to be pathognomonic of this disease. A lateral radiograph (*Fig* 1517) frequently displays the abscess, and there is sometimes a forward displacement of C.2 on C.3 due to spasm of the retropharyngeal muscles (E. H. Townsend). If unopened the abscess ruptures into the oropharynx in 90 per cent of cases, but in 10 per cent death occurs from extension of the abscess into the mediastinum, pneumonia, or rupture of the abscess in such a manner as to asphyxiate the patient

Fig 1517.—Radiograph showing an acute retropharyngeal abscess. (*Dr E H Townsend.*)

Treatment.—The sooner an acute retropharyngeal abscess is opened the better A child is wrapped and pinned in a blanket, so that its arms and legs are immobilized. The patient is held nearly upside-down with the head grasped firmly by a second assistant. No anæsthetic is necessary A protected scalpel (*see Fig* 1315 B) is prepared. The mouth is held open by a tongue depressor a mouth-gag is rarely required. The gloved index finger is used as a guide (*Fig* 1318) A vertical incision is made into the swelling The inverted

[1] Chronic retropharyngeal abscess secondary to tuberculosis *of a cervical vertebra* is central in position. Chronic retropharyngeal abscess secondary to breaking-down retropharyngeal lymph-nodes usually is to one side of the middle line.

position ensures that pus and blood are not aspirated. As a rule drainage is satisfactory but in order to ensure continued and complete evacuation of the pus, sometimes it is necessary to introduce a hemostat into the incision and open its jaws a few days after the operation.

In older children and adults, when there is no serious dyspnœa, a general anæsthetic can be employed. The position of the patient is of the highest importance. It is the same as that described for peritonsillar abscess, when a general anæsthetic is employed. The

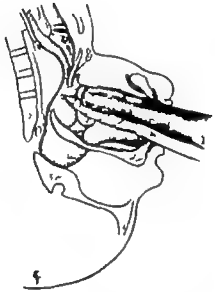

Fig. 1318.—Acute retropharyngeal abscess. With the patient held nearly upside down, the index finger acts as a guide and a guard; the finger reaches the abscess, into the middle of which the protected scalpel is thrust boldly.

mouth is held open with a gag and the tongue drawn forwards with a towel-clip. A tongue depressor is useful for exposing a low abscess. The technique of opening the abscess does not differ from that depicted in *Fig.* 1318.

To employ, whenever possible, two suction apparatuses, is a wise injunction, for not only is the pus likely to be evacuated in half the time (thus minimizing the chances of it passing into the trachea), but should one sucker become blocked, the predicament of being unable to remove pus from the pharynx except comparatively slowly by means of swabs, is circumvented.

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CHAPTER XCI

SURGICAL EMERGENCIES IN THE TROPICS: GENERAL PRINCIPLES

By A. T. Andreasen, F.R.C.S.E., F.R.S.E., F.I.C.S., Lt. Col., I.M.S. (Rtd.)
Lately Professor of Surgery, Calcutta Medical College

Tropical surgery embraces all well-known emergencies, as well as certain conditions unknown or uncommon in temperate climates.

Concomitant Diseases.—Many if not most patients admitted as acute surgical emergencies are also suffering from such tropical diseases as malaria, filariasis, chronic dysentery, bilharziasis, intestinal worms and parasites, leprosy or kala-azar. A large number of them have also one of the more common cosmopolitan diseases, notably tuberculosis or syphilis. Obviously a surgeon cannot depend upon physicians to recognize these diseases for him; consequently it is quicker and more productive of accurate results when examining a patient to have the blood, fæces, urine and sputum, sent at once to the laboratory.

When possible, the following investigations are carried out:—

1. *Blood*.—Advances in tropical hæmatology make it necessary to obtain expeditiously a hæmoglobin estimation, a red blood cell-count, or a white-blood cell-count, a P.C.V. (proportion of cells to plasma), and a report as to whether sickle cells or blood parasites are present.

2. *Urine*.—A report on the specific gravity, the chloride content, examination of a Gram-stained film, and an examination for the ova of bilharzia.

3. *Fæces*.—Examination for the ova of worms and for *Entamœba histolytica*.

4. The patient should be weighed and a clinical estimate of the state of dehydration or fluid retention is most important.

As a precaution against intercurrent malarial complications in surgical patients during the transmission season pyrimethamine 0·25 G. given once a week, or chlorguanide 0·1 G. daily, to each patient will prevent much diagnostic confusion, as well as many post-operative alarms.

MALNUTRITION

Evident or incipient malnutrition is the most important general factor to be taken into account in tropical practice. Rich and poor alike eat an unbalanced diet and suffer from protein and vitamin deficiencies, chronic bowel disease, parasites, anæmia, and poor liver or kidney function, and in women a constant drain of child bearing.

Added to the careful clinical examination of an emergency case, the following data will help to decide the state of nutrition: (1) Estimated proper weight by tables. (2) Observed actual weight. (3) Plasma-protein ratio. (4) Diet and bowel history. (5) Urinary output and fluid intake history, and (6) the hæmatological data noted above.

Whenever the emergency permits sufficient delay, malnutrition should be combated, and incipient malnutrition corrected as far as it is possible during the time at one's disposal. The regime includes correction of fluid and electrolytic imbalance, the administration of protein hydrolysate intravenously, and blood transfusion in case of need. To every child and to every woman in the child bearing period at least [illegible]00 mg. of vitamin B_1 (thiamin) should be given pre-operatively, and repeated twice daily for the first four post-operative days. Many cardiac fatalities are avoided by these means. Mixed vitamins are given intravenously (see p. 31) at first, and as soon as practicable by mouth; they are continued until the patient's discharge.

After operation, as soon as the patient regains consciousness, unless oral feeding is contra-indicated, the following routine is recommended. A Ryle's tube is passed transnasally and tap water is gravitated into the stomach at the rate of 60 drops a minute for 24 hours. During the second 24 hours skimmed milk is added to this drip. The mixture is gradually reinforced with whole milk, protein digest, and dextrose until by the fifth day about [illegible]

of protein and 4000 calories are being supplied. The common fatal post-operative complications of malnutrition i.e., post-operative shock, œdema, faulty wound healing and oliguria, will be greatly minimized thereby.

The value of transnasal intragastric, high calorie drip feeding has been proved among the chronically undernourished populations of the tropics.

Ultra-severe malnutrition in early childhood (kwashiorkor) sometimes causes lesions which simulate full thickness burns or scalds of the skin; operation in such cases is almost uniformly fatal.

Acute Abdominal Emergencies arising from Primary Carcinoma of the Liver (see p. 1100)

DEHYDRATION

Every patient admitted as a surgical emergency in tropical practice must be viewed from the angle of fluid balance. Apart from losses consequent upon vomiting and/or diarrhœa, it must ever be before one that enormous losses result from sweating, especially during an operation and while the patient is still under the anæsthetic. The surgeon may lose 4 lb. (1800 G.) in weight in the course of one hour's work. What, then, must be the loss in a patient whose heat regulating mechanism is impaired during that same hour and for some time post-operatively? Further, it must also be taken into consideration that frequently these enormous losses are taking place in a patient whose fluid balance is chronically deranged by severe anæmia and plasma-protein deficiency. It is likely that the usually low blood pressure of about 110/60 mm. Hg encountered may be due to a chronically contracted blood-volume. With such a blood pressure the hæmoglobin is often only 40 or 50 per cent of normal, and the red blood-cells 3,000,000 per c.mm.; thus compensation has occurred but with dilution and contraction. Without blood volume studies—not often available to a surgeon in tropical climates—no information can be obtained as to the extent of the compensation in any given case.

With excessive sweating added to this state of affairs, the position becomes so confused that it is only with great care and resort to laboratory investigations that the surgeon will be able to estimate the fluid needs of the patient. Haphazard administration of water and electrolytes, plasma-volume expanders, or whole blood must be eschewed as too often their over administration swings the pendulum against the patient's recovery. More and more Centres in the tropics are now becoming equipped with laboratory facilities for checking the patient's fluid, water, electrolyte, and whole-blood requirements. In the absence of these facilities some empirical clinical rules are as follows:—

1. **Blood Transfusion.**—In an adult blood transfusion should be given in increments of 250 ml. only at a time, unless some fairly accurate estimate of the blood loss is possible, e.g. blood vomited, the increased weight of swabs soaked at operation.

In an infant, 10 ml. per lb. of body weight should never be exceeded, and only one-quarter or one-third of this amount is transfused at one time.

2. **NaCl Replacement.**—The normal 10 G. daily requirement must be given slowly, after which a clinical estimate is made based on the presence of moist lips and tongue, normal skin elasticity, the absence of œdema and thirst, a urinary output of at least 1000 ml. in 24 hours with a specific gravity below 1020, and the presence of adequate chloride excretion. By these criteria excessive doses of sodium chloride will be avoided.

The differentiation between the low plasma-sodium due to the dilution and that caused by depletion is summarized by Professor C. G. Rob as follows:—

	Dilution	Depletion
General appearance	Drowsy; mental change; fits	Alert, apprehensive
Tongue	Moist	Usually dry
Eye tension	Normal	Low
Pulse-rate	Normal	Raised
Temperature	Normal	Low
Blood-pressure	Normal	Low
Hæmatocrit	Low	High
Urinary—Volume	Normal	Usually low
" Specific gravity	Low	High
" Electrolytes	Low	Low

The maximum safe expansion of extracellular fluid spaces is roughly to the extent of 10 per cent of body weight. Given the patient's weight in kilos, 3 per cent of this total can safely be given over 8 hours. The total should include water, salt, dextrose and dextran, in proportions indicated by the nature of the individual case in respect of oligæmia and dehydration.

Intestinal obstruction and post-operative paralytic ileus are very common in tropical practice, hence in these conditions to the above requirements must be added a volume equal to that of the fluid aspirated via an indwelling gastro-intestinal tube. At all times the keeping of a very careful fluid balance chart is imperative.

It is often said that in the tropics water can be safely given in almost any quantity and on first hearing it one is inclined to accept such a statement because of the amount of fluid lost by sweating. Of all the rules of thumb to which from time to time we have recourse, this is the most dangerous. Acute water intoxication, with fits, coma and death, is as easily provoked in the tropics as elsewhere.

ACUTE ŒDEMA OF THE LUNGS; CHRONIC HYPOPROTEINÆMIA AND FEEDING

It is not uncommon to be called to see a patient recently operated upon, whether as an emergency or not, in whom fluid therapy has been instituted, and one is told that the heart is failing. In a population in whom chronic hypoproteinæmia is the rule, a constant and careful watch must be kept for patchy œdema around the buttocks, on the back and face, and œdema of the lungs. It may appear suddenly; it may flit from place to place or it may remain constant and spread. In patients sufficiently dehydrated as to require plasma volume restoration the replacement can easily be too quick, too generous, or too energetic for the particular case. Calculated plasma protein may have been apparently normal because of hæmoconcentration. In such cases the diagnosis is not one of heart failure, but of reduced albumin fraction in the plasma. It is better to leave such patients slightly dehydrated whilst building up the albumin fraction.

Beef is a better plasma-protein builder than casein, since 100 G. of beef will give 38 G. of plasma protein, while the same quantity of casein will only give 10 G. of plasma-protein. Lightly boiled and pounded liver, 300 G. daily, is a useful addition in these cases, having a beneficial effect within three or four days.

It is useful to bear in mind that surgical intervention or trauma causes a breakdown of body protein at the rate of about 2 lb. (900 G.) per day. In cases of intestinal obstruction, severe infection or heavy active parasitic infestation this rate is approximately doubled. These remarks are poignant illustrations of how important is proper feeding in tropical practice.

BLOOD TRANSFUSION

The setting up of small blood banks at most of the largest tropical hospital centres gives great encouragement, being evidence that some of the racial, social and religious barriers to the use of blood transfusion among native patients are breaking down. This does not mean that the high incidence of endemic disease can be disregarded: the greatest care will always be necessary in the screening and grouping of donors and recipients. At present the scarcity of volunteers, both as donors and recipients, together with the distressing shortage of staff, are factors which militate against the rapid expansion of the Blood Transfusion Services in tropical countries.

The following data have been accepted as being practical (G. M. Edington):—

1. Ignore the hazard of malaria, using amodiaquin (camoquin)[1] 0.6 G. as a single therapeutic dose by mouth, to both donor and recipient immediately after completing the transfusion in partially immune individuals; add 0.4 G. on the following two days in non-immunes. Chloroquin sulphate 0.4 G. intramuscularly daily for two days, will protect those too ill to take the drug by mouth.

2. A rise of temperature to 99° F. (37.2° C.) within ten days of transfusion calls for a full hæmatological examination.

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[1] Parke Davis & Co. Ltd., Staines Road, Hounslow, Middlesex.

3. A positive Kahn test should exclude a donor if possible Otherwise a covering dose of penidural[1] 1 2 mega units, with distaquaine[2] 0·3 mega units, should be given 24 hours before withdrawing blood

4. When there is no alternative it is permissible to use sickle-positive blood provided the donor is entirely suitable in all other respects.

5. Illiteracy renders the history of many donors unreliable and so there is an increased risk of transmitting homologous serum jaundice However Edington reports no case of this kind in his experience

6. Blood for cross-matching must be withdrawn from the recipient before dextran or another volume expander is given; these blood substitutes cause rouleaux formation and false agglutination of compatible donor cells.

7 AS and AC blood[3] have been successfully stored and transfused

8. The most likely cause of serious accident is overloading Few patients have a hæmoglobin estimation of over 65 per cent and the average is below 50 per cent. They are chronically hypoproteinæmic and long since have established a permanent state of compensatory contracted blood volume (see p 1085). Very careful judgement and personal supervision of the whole transfusion by the doctor is the only way of avoiding accidents

9 The standard of care of apparatus, preparation of distilled water washing of tubing, etc., is so much lower than in Europe or America that a 10 per cent incidence of pyrogenic reactions must be expected. The use of chlortrimeton,[4] 10 mg per 500 ml directly added to the flask of infusion or blood is advised for safety unless the newer polythene sterile packs[5] are used, and discarded after use

10. It should not be forgotten that for the average indigene the donation of 1 pint (430 ml.) of blood is a very generous gift and to him is due some care and attention after being bled in order to enable him to make good some of the loss involved to his probably subnormal store of erythrocytes.

GUARDING THE (UNCONSCIOUS) PATIENT AGAINST THE EFFECTS OF EXCESSIVE CHANGES IN TEMPERATURE

Temperature conditions in the wards and in the operating theatre should be under constant observation so that the patient is not subjected to excessive cooling in the one or overheating in the other whilst his temperature regulating mechanism is out of control from effects of anæsthesia. Carelessness in this precaution often precipitates shock in the highly acclimatized, but chronically anæmic, native and shock and heat-stroke in poorly acclimatized foreigners.

It is wise to have close to the operating theatre a recovery room, in which the temperature is intermediate between that of the cool operating theatre and the warm ward

HEAT STROKE

Racial Differences.—Except under conditions of deep mining, heat-stroke is less common among dark-skinned races than among white persons.

Prevention.—From the description of treatment which follows, it will become apparent that one patient with heat stroke requires the undivided attention of one doctor and at least two nurses or orderlies for a very long period. Lest, through want of forethought, several patients be stricken simultaneously it is of cardinal importance that an efficient organization is maintained to prevent wards becoming overheated. It is not possible to deal here with this vital administrative problem but it is relevant to emphasize that a surgeon practising in the tropics must inaugurate, in every ward under his charge, a system whereby a wet bulb thermometer reading is recorded twice daily and reported to him when the reading is higher than 70° F (21 1 C) Another practical precaution is for the surgeon

[1] Penidural All-purpose (John Wyeth & Brother Ltd., Clifton House, Euston Road, London, N W 1). This preparation of penicillin is given orally

[2] Distillers (Biochemicals) Co. Ltd., 8–12 Torphichen Street, Edinburgh, 3. Given intramuscularly

[3] AS and AC refer to abnormal hæmoglobins The A signifies the normal adult hæmoglobin and the S and C two hæmoglobins that occur fairly frequently in tropical countries.

[4] Chlortrimeton British Schering Ltd., 229 Kensington High Street, London, W.8

[5] Poviet Production N V., Mauritskade, 14 Amsterdam, Holland.

on his daily round to make a practice of taking each patient's hand in his: an individual whose skin is hot and dry is a candidate for heat stroke. It is of the greatest importance that night staff be reliable and specially instructed to watch that the system does not break down as well as to watch for suspicious symptoms in patients.

No matter from what the patient is suffering, if his temperature is rising and be has a dry skin, headache, tachycardia, a sensation of warmth and dizziness, injected conjunctivae, urinary frequency and polyuria, he should be regarded as suffering from heat-stroke and treated accordingly. Investigations to eliminate other common causes of hyperpyrexia *follow* and the first of these is repeated examination of thick blood films for malaria parasites.

Treatment.—Remove the patient to a room cooled with fans. This room should be shaded, but it must be well ventilated, otherwise the air will become super-saturated with moisture. Place the patient flat on his back on a bed furnished with a light khus-khus[1] mattress that has been covered with a blanket. Under the bed is a large tub to receive the water which will drip through the mattress. An ice-cap is applied to the head and ice-bags to the neck and groins. Over the naked patient is placed a sheet, continuously wet with really cold water from a watering-can (*Fig.* 1510). Ice-water, i.e., water with lumps of ice floating in it, is too cold: the aim is to cool the patient less precipitously by evaporating the water in contact with his skin. To this end a table fan is so placed that a current of air is directed on to the patient.

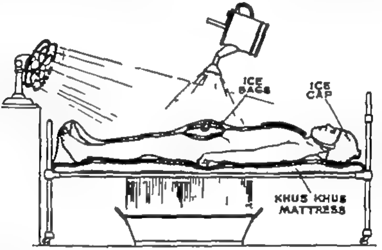

Fig. 1510.—Cooling system described in the text. Ice bags to the neck are omitted for the sake of clarity.

Recording Progress.—The temperature is taken per rectum every fifteen minutes and recorded on a chart. In addition, the blood-pressure should be taken and charted hourly or more often if required. Fluid intake and output must be similarly recorded; a note of the presence or not of albumin and chloride in the urine must be made; the pulse-rate should be recorded graphically with the temperature. If circumstances permit *repeated* blood specific gravity, Na and K estimations, etc., should be carried out from admission, and this data, taken in conjunction with the remarks under dehydration, will provide a basis and guide to fluid therapy and response in the patient. This data should be recorded graphically.

By this means all the required data and the trend of the case can be seen at a glance. Wet-bulb atmospheric thermometric readings are also recorded on the patient's chart every six hours.

Treatment when the Atmosphere is very Humid.—When the wet bulb reading rises to between 78° F. (25·6° C.) and 83° F. (28·3° C.) sufficient evaporation to cause adequate lowering of the temperature cannot occur. In these circumstances the patient must be placed in a bath of cold water, changing the water by a syphon system from a raised tub of ice-cold water. Vigorous massage in the bath, together with the administration of oxygen, is helpful.

[1] Khus-khus is a kind of straw.

Alternative Method of Reducing Hyperpyrexia.—The apparatus consists of a fine polythene tube with a finger-stall (which, on inflation, will hold 250 ml.) tied securely on to one end. The other end is attached to a two-way tap connected to a 50-ml. syringe. The inlet tube connected to the side channel of the two-way tap is placed in a bowl of water at about 39° F. (4° C.). The balloon tipped tube is passed into the stomach and irrigations are carried out once every five minutes, each change of water remaining in the balloon for three minutes. The method reduces hyperpyrexia to normal limits within an hour (H. H. Khalil and R. C. MacKeith).

Additional Measures to be taken in Special Circumstances.—A systolic blood pressure of less than 100 mm. Hg and body temperature over 106° F. (41·1° C.), central nervous system signs, loss of knee-jerks, anginal pain and a history of alcoholism indicate a very poor prognosis, and call for the administration of noradrenaline as in cases of shock (*see* p. 77). Penicillin should be given to all comatose patients and chloroquin 0·4 G. intramuscularly is advisable in any patient whose temperature rises above 102° F. (38·9° C.). Chlorpromazine 50 mg., two to four hourly is valuable in controlling hyperpyrexia and has the advantage of not inducing or inhibiting sweating. Signs of cardiac embarrassment, and especially angina pectoris, can be relieved by venesection. One pint (450 ml.) of the patient's blood is allowed to gravitate into a sterile transfusion bottle which is stored. When the patient's condition improves, his blood is returned as a transfusion.

Heat Stroke and Cerebral Malaria can be clinically indistinguishable; malaria definitely predisposes to heat stroke. In malignant tertian malaria repeated blood films may be negative for the first two or three days. For these very reasons the reader is strongly advised to add to his therapeutic régime in any case of hyperthermia :—

1. Chloroquin, 0·4 G. intramuscularly.
2. For a child —1 year [illegible] dose.
   1–3 years [illegible] „
   3–6 „ [illegible] „
   6–9 [illegible] „

Parenterally : 5 mg. per kilo of body weight is a maximum.

Response to Treatment (all cases).—When the patient's temperature has been lowered to 102° F. (38·9° C.) he should be dried and put naked into a dry bed. An ice-cap is still applied to his head. The longer the rectal temperature remains satisfactory the more favourable becomes the prognosis. Nevertheless, sudden relapses are common even after the patient appears to be convalescent; consequently unremitting nursing attention is essential. Relapses call for a resumption of the therapy as already detailed. Recurring relapses warrant an increasingly poor prognosis.

Return to normal sweating requires at least four weeks, and often as long as twelve weeks. In these circumstances sudorific drugs fail to provoke sweating and may exacerbate symptoms.

The crisis is over. A patient who has recovered from heat stroke often registers a low fever for several days. Not infrequently he is mentally torpid, lacks the power to concentrate and suffers quite severe headaches. In the event of such symptoms persisting for more than a few weeks, the surgeon should recommend and insist that the patient leaves the Tropics if that be possible. Occasionally definite signs of increased intracranial tension due to cerebral œdema become manifest. Cerebral œdema should be treated as described on pp. 98, 1106.

SUBDIVISION OF THE PHENOMENA OF HEAT STROKE

Heat stroke can be properly divided into three categories :—

1. Heat fever, which is the most urgent and dangerous, and has been dealt with at some length.

2. Heat exhaustion is more common than was formerly believed; a mild form is frequently encountered in white people resident in the tropics.

3. Heat cramp.

Heat Exhaustion may be the primary condition; more often it follows heat fever just as the crisis appears to be over. The patient's temperature falls to below normal, he breaks into a cold sweat, and the pulse becomes rapid, irregular and thready. The condition simulates shock.

Heat exhaustion takes a more chronic and less well-defined form in the dark-skinned peoples, therefore it is not so easily detected, but judging from empirically applied therapy it does occur. The response, however, is less satisfactory.

Prevention.—I have encountered fewer of these cases since intravenous saline and oxygen therapy have been incorporated in the programme of treatment of heat fever.

Treatment.—Resembles in all particulars that of shock. Nevertheless, it must be constantly remembered that malignant malaria may simulate heat exhaustion exactly. Consequently, the only safe method of procedure is to take repeated thick blood-films and administer chloroquin together with treatment as for shock. A constant watch is necessary since incredible rises of temperature and changes in the clinical condition can take place in a matter of minutes. On promptitude in treating the exacerbation depends the patient's chance of survival.

Heat Cramp.—Unless sufficient water containing 10 gr. of common salt to the pint is imbibed by those doing manual work under conditions where the wet-bulb reading stands at 158° F. (70° C.) or over, muscular cramps soon develop. Naturally, the heavier the work and the higher the atmospheric temperature and humidity, the greater is the liability to this condition. I have experienced the malady myself after particularly arduous work in the operating theatre; now during the hot season I make a practice of drinking a pint of salted lemonade between operations.

SURGICAL EMERGENCIES AND MALARIA

Malaria in relation to Trauma and Sepsis.—Often even a minor injury arouses latent malaria. For instance, a man is admitted having received a trivial injury to his shin a day or two previously. He now has a high temperature and diffuse tenderness over the tibia. Should the blood-slide reveal benign or malignant tertian rings, chloroquin (150 mg. per tablet), 4 tablets at once in the partially immune, or 2 tablets t.d.s. for three days in the non-immune, will cut short the symptoms and signs within forty-eight hours. Patients suffering from sepsis *and malaria* recover more slowly if the malaria is not treated vigorously.

Slight trauma in infants and children native to the tropics, and especially where malaria is hyperendemic, may be followed by prodromal signs of cerebral involvement by the parasites. Treatment must be prompt and adequate, if tragedy is to be avoided.

Malaria and Acute Abdominal Condition: General Principles.—Malignant tertian especially may simulate any surgical abdominal condition, but more often appears concurrently with surgical disease than as the cause of simulation. Suspected or proved malaria is to be regarded as an unwelcome addition to be treated collaterally but never to outweigh any imperative sign present, e.g., rigidity. To open an abdomen unnecessarily is less regrettable than to treat an acute abdominal catastrophe as malaria.

Since parasites may be found in blood-slides without clinical signs, it is good practice not only to make routine pre-operative blood-slides but at operation to use any available visceral blood or blood-stained peritoneal fluid similarly. These sources may be positive when others are negative. Finding parasites will perhaps explain symptoms in the absence of surgical lesions, but, more important, will lead to treatment and avoidance of a worrying post-operative period for which such patients are candidates. Further, the surgical patient responds more quickly if a subclinical malarial infection can be found and eliminated.

Malaria as a Cause of Post-operative Pyrexia and Hyperpyrexia requires careful consideration, even when the pre-operative blood-smears were negative.

It is a good practice to give all patients who are to undergo an urgent operation chloroquin, 0·4 G. intramuscularly, regardless of clinical or microscopical evidence of parasites. This practice helps to avoid shock and other complications.

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CHAPTER XCII

ABDOMINAL EMERGENCIES IN THE TROPICS

By A. T. Andreasen, F.R.C.S.E., F.R.S.E., F.I.C.S., Lt.-Col. I.M.S. (Rtd.)
Lately Professor of Surgery, Calcutta Medical College

ACUTE APPENDICITIS IN THE TROPICS

Although acute appendicitis is not common among the natives of tropical countries, when it does occur inflammatory changes often proceed apace with early perforation and peritonitis. Not infrequently the patient will first present with rigors and jaundice due to pylephlebitis consequent upon delay in seeking advice.

It must be realized that an acute right iliac fossa syndrome in a native is commonly part of a more disseminated affection—e.g., amœbiasis, schistosomiasis, filariasis—and only rarely is it the condition known as "appendicitis" in temperate climates. In this chapter the term "appendicitis" is used *descriptively only*.

Appendicitis due to Bilharzia Ova is not an uncommon condition in those parts of the world where bilharzia is a prevalent infestation, i.e. North, West, East, and Tropical Africa, and in Venezuela. It is emphasized that every appendix removed in the Tropics and related areas should be scraped carefully and the scrapings examined for parasites and ova. The discovery of bilharzia ova will lead to a full investigation of the patient with a view to finding and treating bilharzial polyposis and stenosis of the colon and rectum, which is so common in this condition.

Typhoid Perforation of the Intestine.—(*See* p. 206.)

Typhoid Perforation of the Gall bladder.—(*See* p. 319.)

EMERGENCIES ARISING FROM "COLITIS"

The term "colitis" is employed here advisedly. It does not imply any particular disease but embraces all of those inflammations of the colon, notably the dysenteries, intestinal schistosomiasis and worm infestations that abound in the tropics.

Acute Appendicitis or Colitis?—This is a constantly recurring problem requiring considerable surgical judgement. To operate upon a patient with amœbic dysentery is to invite an exacerbation of colitis that may prove fatal.

A nursemaid, aged 24, stated that she had had recurring attacks of right-sided abdominal pain. Careful inquiry did not substantiate a history of colitis. The present attack came on with great suddenness, and on examination I came to the conclusion she was suffering from acute appendicitis. Appendicectomy was performed, but the appendix appeared normal. All went well until 2 p.m. on the fifth day. A slight pyrexia, 99° F. (37·2° C.), suddenly gave place to hyperpyrexia with rigors. This was followed four hours later by a subnormal temperature. About this time profuse bloody diarrhœa set in, and was followed four hours later by the expulsion of a slough of mucosa 18 in. (45 cm.) long, which in turn gave place to the passage of pure blood. In spite of all resuscitative measures, she died in agony in the early hours of the morning. At necropsy amœbæ were freely obtained from the mucosa of the terminal ileum and the large intestine.

This severe lesson, while being a warning, must not prejudice the surgeon. Although the differential diagnosis is difficult, it is not impossible.

In the case of the pseudo-appendicitis of colitis, rigidity is usually absent. As is well known, in acute appendicitis usually the pain moves to, and does not commence in, the right iliac fossa. Routine sigmoidoscopy is of great value in detecting signs of amœbic or bacillary infection. If real doubt still exists, 1 gr. (0·06 G.) of emetine hydrochloride in 20 ml. of normal saline should be given intravenously very slowly. If the condition is due to amœbic dysentery there is likely to be a substantial amelioration of symptoms within two hours. Occasions arise when there is no dramatic improvement, in which case it is safer to operate in spite of the fact that amœbic infection has not been ruled out. Perforation of the base of the cæcum or appendix, or obstructive inflammation of the latter, frequently results from

amœbic ulceration causing local peritonitis that is prone to spread Should the appendix appear to be comparatively normal on the outside in due course the interior must be scrutinized. As soon as possible the organ is opened and scraped and the material from the lumen examined microscopically for parasites; cultures should also be prepared. In cases of pseudo-appendicitis of dysentery it is of the highest importance to start a full course of emetine therapy combined with full doses of a long-acting penicillin preparation and thalazole (May & Baker Ltd.). *It is equally important to realize that such therapy may be ineffective if readjustment of fluid and plasma protein of carbohydrate and mineral losses are not made good as soon as possible*

The Pericæcal Abscess of Colitis.—Entamœbic colitis can give rise to another syndrome A patient is admitted with a lump in either the right or left iliac fossa. When right-sided the question of appendix abscess arises, but in this instance the decision as to the immediate diagnosis is not so onerous as in the case of acute right iliac fossa syndrome without a lump, for the correct procedure is to adopt the Ochsner Sherren régime (see p 232) With emetine therapy a hypertrophic mass due to the entamœba *unmistakably decreases in size* and consistency it is no exaggeration to state that the lump melts daily The dose of emetine recommended varies from ½ gr (10 mg) to 1 gr (0·06 G) intramuscularly daily for 10–21 days. *The minimum total dose is 5 gr (0·3 G) and the maximum total dose is 12 gr (0·8 G)* In spite of new therapeutic agents of great power—e.g., chloroquin camoform, erythromycin—emetine remains a drug unrivalled for the control of this condition.

Filarial Infestation of the Deep Iliac Lymph nodes.—*A mass which fails to resolve or suppurate* may be due to filarial infestation of the deep iliac lymph-nodes—a possibility that is worthy of full consideration in certain areas of the Tropics. These masses arise with acute symptoms, suggesting the onset of a deep abscess. Symptoms of acute intestinal obstruction are a not infrequent accompaniment but there is usually a good response to enemata. These masses resolve with heavy doses of penicillin, chloromycetin, or streptomycin, and appropriate body-weight doses of diethylcarbamazine, given with regard to the local type of filaria.

Chloromycetin in *full doses with diethylcarbamazine have proved an effective combination.*

Peritonitis accompanying Colitis.—Adhesive pericolitis is so common that in cases of colonic perforation sudden diffuse peritonitis seldom occurs. The perforation takes place *quietly because of veil like pericolic adhesions, which limit the leakage for a number* of hours. The escape of such virulently infected fluid soon results in abscess formation and because the limiting barriers are thin and friable it is not long before fæculent pus bursts into another peritoneal pocket or burrows *into an adjacent loop of intestine Thus we are* confronted with the misleading clinical picture of a relatively uncomplaining cachectic patient who really has a creeping intraperitoneal infection that Nature seldom seals off sufficiently to prevent eventual total involvement and disaster

A colonic perforation must be strongly suspected in any patient giving a history of dysentery or diarrhœa —

a. When his abdomen suddenly or comparatively suddenly becomes distended and silent. If he suffered from diarrhœa, and this ceased at the time of the onset of the distension, little further evidence *of colonic perforation is required.*

b When his condition suddenly but indefinably changes for the worse. Often such a change is ushered in by shivering a fall in temperature, and a rising pulse-rate. These signs are especially suspicious if accompanied by vomiting or hiccup

c While a sudden onset of violent abdominal pain is unusual a complaint of abdominal pain calls for repeated abdominal examinations. It is by such constant watchfulness that transitory localized rigidity as opposed to tenderness, will be discovered. Localized rigidity in these unresponsive subjects indicates a hopeful prognosis, because the diagnosis has not been delayed unduly

Treatment —Laparotomy should be undertaken as soon as emetine and penicillin therapy have had time to take some effect (two hours or more) and the fluid balance has been restored. General anæsthesia is employed if the services of a skilled anæsthetist are available. In other circumstances local anæsthesia, with thiopentone given into the drip if necessary or spinal anæsthesia, is *substituted. Either a vertical or a transverse incision* centred over the site of maximum tenderness can be used. I prefer a transverse incision because of the excellent access it gives to the paracolic gutters, which are so often the site of abscess formation in this condition. Usually it will be found that the whole or part of the colon is thickened and friable, with multiple sieve-like perforations, so that exteriorization after mobilization

is arduous or impracticable. Terminal ileostomy (see p. 520) should be performed and the abdomen closed with suprapubic drainage and also drainage to the sites of perforation. Often these are extraperitoneal into one or other of the paracolic gutters.

Post-operative emetine, chloromycetin, and penicillin, given together rapidly overcome the severe mixed infection. It should be borne in mind that natives are generally in a state bordering on vitamin B deficiency and therefore chloromycetin should be accompanied and followed by the administration of a resistant strain of *Lactobacillus acidophilis*.

Fig. 1520.—Patient six weeks after closure of the ileostomy with resection of the right half of the colon and ileotransverse colostomy.

At a later date the continuity of the intestine can be restored if need be after excision of a stenosed segment (*Fig.* 1520).

Intestinal Obstruction associated with Colitis is very common; most frequently the subacute as opposed to the acute variety of this condition is presented. Consequently the greater number of cases fall into the category of quasi-emergencies, and there is ample time to investigate the large gut by means of stool examination, sigmoidoscopy and, if facilities exist, by barium enema. In this way cases of colonic spasm, as opposed to an organic obstruction, can be segregated. While sometimes the obstructive symptoms are due to spasm alone, more often the spasm is associated with organic partial obstruction due to extra intestinal inflammation (abscess or amœbomata), fibrotic stricture of the intestine, or an intussusception.

Amœbomata are of two varieties:—

1. *True amœbomata* are fibrolipomatous tumours involving the whole thickness of the intestinal wall; they are œdematous, hard, and nodular. They are persistent, only partially reversible and are often confused with carcinomata.

2. *Ulcerative amœbomata* are penetrating ulcers surrounded by an intense inflammatory reaction. With vigorous treatment these lesions are reversible.

Both types of amœbomata are associated with hard mesenteric lymph-nodes; both cause intestinal obstruction by one or other means. The first type always requires resection of the involved intestine; the second type may resolve entirely or leave residua requiring resection.

Usually the subacute character of the intestinal obstruction produced by amœbomata gives the surgeon ample time to correct dehydration, empty the upper alimentary tract and give prophylactic emetine and thalazole.

While these preparatory and therapeutic measures are in progress, frequent re-examination of the patient is imperative in order to catch fleeting clinical signs of importance, e.g. rigidity. In all but the moribund, considerable improvement in the general condition is bound to occur. As in all cases of intestinal obstruction occurring anywhere on the globe this general improvement must not lull the surgeon into procrastination in cases where clinical judgement dictates that an organic lesion is the underlying cause.

The surgeon, especially one without tropical experience, must beware of the adhesions he will find in the 'colitis abdomen'. These may be filmy and swept aside easily. Quite often they are firm and the colonic wall to which they are attached is of the consistency of wet blotting paper. So it comes about that unless the operator proceeds with the utmost gentleness, employing sharp rather than blunt dissection, and keeping well away from the wall of the gut, almost before he realizes it a rent will appear in the colonic wall. An outpouring of fæcal fluid into the peritoneal cavity, always a grave complication, in this instance is almost certain to determine a fatal issue.

The surgeon is also advised to regard the 'colitis abdomen' as a hotbed of latent, if not active peritonitis. Consequently he should aim at disturbing adhesions as little as possible. Unless there is an obvious band or other easily remediable condition found causing the obstruction, it is often in the patient's best interest to make an early decision to perform terminal ileostomy, for it must be remembered multiple lesions are present throughout the colon.

Terminal (syn. Disconnected) Ileostomy is a splendid life-giving procedure in several of the surgical complications of colitis. The indications for its performance are :—

1 *Acute Colitis (including acute relapse)*.—Persistently raised temperature. Deep tenderness over the whole colon Frequent foul bloody stools. Rapid deterioration of the patient

2 *Chronic Colitis.*—It may be urgent where threat of or actual cachexia, rapid loss of flesh, large shreds of membrane in stools, much pus, repeated small hæmorrhages, and dissociation of pulse and temperature occur

3 *Complications of Colitis*.—Intestinal obstruction perforation advancing pericolitis and perirectal or perianal conditions not responding to treatment

4. Failure to respond to specific therapy

While the operation is rightly looked upon as an emergency procedure the patient must never be rushed to the theatre in an unprepared state. For its successful performance he must be prepared properly by utilizing emetine and penicillin sulphaguanidine or sulpha suxidine therapy adjusting fluid balance correcting hypoproteinæmia and anæmia. When obstructive symptoms are present the use of an indwelling gastro-duodenal tube is, of course a necessity The post-operative care should include a continuation of these measures according to the patient's needs, as well as suitable chemotherapy It is the performance of ileostomy without full regard to its accessory requirements which has brought the operation into disrepute with some physicians.

As ileostomy will often be the last step of an urgent abdominal operation upon a patient suffering from colitis this is an occasion where it pays to hasten slowly for everything depends upon a satisfactory stoma being established. The terminal 2–3 ft (60–90 cm) of the ileum are inspected and palpated for evidences of thickening or inflammation It is not uncommon to find that this part of the small intestine is the seat of demonstrable dysenteric infection. A loop of indubitably healthy ileum must be chosen for constructing the stoma. The technique of terminal ileostomy is described on p. 520.

A close watch must be kept on the skin surrounding the stoma for the appearance of ulceration, which is likely to be amœbic in origin With proper care of the stoma and treatment of the underlying condition this complication rarely supervenes.

Intestinal Obstruction due to Bilharzial Infestation.—While in the foregoing account emphasis has been placed on the complications that can, and do arise frequently from colitis due to *Entamœba histolytica*, the fact that other infestations such as bilharzia can give rise to colitis and its complications must not be lost sight of Bilharzial infestation gives rise to multiple large or small pedunculated polyps (containing ova) which can often be seen by sigmoidoscopy within three months of infestation. Much fibrous tissue is laid down within the colonic and rectal walls, and the rigid tubular type stenosis with acute or chronic obstruction of the colon sometimes results. The urgent treatment of such obstruction is to relieve it by performing colostomy cæcostomy or ileostomy according to the site of the obstruction. As soon as the patient has recovered sufficiently local treatment of bilharziasis must be commenced. Retention enemata of 1 G of tartar emetic in 200 ml. of water rising to 3 G. in 450 ml. daily for six days results in much local improvement. Meanwhile, a full course of anthiomaline in accordance with body weight, should be administered by injection. In cases where local fibrous contraction of the colon or rectum has occurred, resection of the affected portion of the bowel is the only method of cure

Acute Abacterial Plastic Peritonitis.—In the Tropics, when the abdomen is opened urgently for peritonitis, once in 1250 cases no cause for the peritonitis can be found. In these circumstances, in all probability the inflammation is due to abacterial peritonitis. The greater part of the parietal and visceral peritoneum is covered with a thick, sticky exudate, and beneath the latter the intestine is red and congested. In such circumstances the abdomen is closed. Cultures, smears, and biopsy for ova have so far proved negative Chloromycetin causes the condition to resolve rapidly

RUPTURE OF THE SPLEEN IN TROPICAL PRACTICE

All over the Tropics this is a frequent vital emergency and one that calls for full exertion of the surgeon's judgement, manual dexterity and resourcefulness. The acute malarial spleen is not much enlarged It is literally a bag of black, fluid, splenic pulp, and rupture of it is nearly always rapidly fatal. Bilharzial and Bengal splenomegalies often rupture as a result of a trivial accident, as do enlarged spleens due to kala azar and typho

while occasionally enlarged spleens due to splenic anæmia are encountered. In addition, there are many splenomegalies of unknown origin, the first intimation of which is rupture. In this condition the surgeon is committed to splenectomy, but in view of the unknown pathology of a great many cases of enlarged spleen in the Tropics, he should expect and will often be taxed with a very stormy post-operative period.

The delayed type of rupture following an injury causing a splenic hæmatoma (see p. 361) is very common, and if a timely correct diagnosis is made and the patient is splenectomized before a catastrophic intraperitoneal hæmorrhage occurs, the prognosis is inconceivably better, as the following figures of my cases substantiate:

Of 46 patients operated upon for splenic hæmatoma, 2 died. (Mortality under 5 per cent.)
Of 91 patients operated upon after the hæmatoma had burst, 63 died. (Mortality 66 per cent.)

The surgeon must constantly be on the watch for cases of splenic hæmatoma (*Fig.* 1521). The history of trauma may be trivial or absent. There is always some initial pain and tenderness in the left hypochondrium. Although the acute pain passes off, it is unusual for the patient to be relatively symptom-free in the interval between the initial rupture and the hæmorrhagic cascade that only too often results in the patient's exodus before surgical aid is forthcoming. This quiet interval, which varies from a few hours to even months, is undeterminable, but it provides an opportunity unequalled in the whole realm of surgery of forestalling inevitable disaster by a timely diagnosis and a well-planned operation.

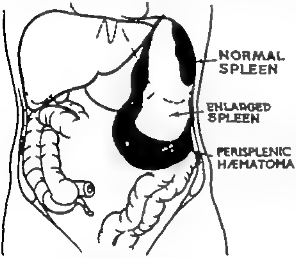

Fig. 1521.—Normal spleen, enlarged spleen, perisplenic hæmatoma. The splenic contour is lost when the capsule has ruptured.

The management and technique of splenectomy for rupture are dealt with on p. 363.

A point of difference between the removal of a spleen of a patient resident in the Tropics and that of splenectomy in temperate climates is that in the former the spleen is not only usually enlarged, but it is adherent. The operation is therefore more difficult, and to forestall probable torrential hæmorrhage in the case of a perisplenic hæmatoma the first step should be ligation of the splenic vessels. This can be accomplished without disturbing the mass of blood-clot by approaching the splenic artery lying along the upper border of the pancreas and the splenic vein situated just behind and below the upper border of the pancreas. The lesser sac is entered either above or below the stomach, whichever is the more convenient. In this way the splenic vessels can be identified easily and ligated. Frequently it is possible to find a plane of cleavage between the parietal peritoneum and the muscle wall, in which case the spleen can be dissected free with less oozing than if intraperitoneal mobilization of the organ is attempted.

As soon as the spleen has been removed and it has been ascertained that the whole pedicle has been ligated securely, a large warm moist pack is pressed firmly into the cavity and held there for five minutes. Various bleeding points will now be revealed and can be ligated. If generalized oozing recommences, sometimes packing the cavity is necessary.

In weak or shocked patients when the spleen is very adherent to surrounding structures, after ligation of the splenic vessels, it is sometimes wise to conclude the operation. In such cases before closing the abdomen, light packing is inserted into and around the seat of rupture. The end of the gauze is brought through a special short left transverse incision. Blood, blood-clot, and necrotic splenic tissue continue to be extruded for a variable time. In 8 cases so treated massive necrosis of the spleen did not occur, and when the patient's general condition had improved, splenectomy was carried out successfully some days later.

Drainage of a Splenic Abscess.—Apart from such blood-borne causes as typhoid, staphylococcal pyæmia, infected hydatid cysts, and amœbic abscesses, this condition is

sometimes due to infection of a splenic hæmatoma; more frequently it is the result of suppurative perisplenitis. Extension of the abscess into the subdiaphragmatic space is not unusual, and when it occurs the treatment is that of a subphrenic abscess. Attempts to confirm the diagnosis by aspiration are to be condemned. *Splenectomy is unsuited to all but special cases of central abscess.* Exposure of the spleen, centreing the incision over the most tender spot is recommended. Having opened the abscess it should be drained by *soft* rubber tissue, as ordinary drainage tubes are liable to invite serious secondary hæmorrhage from pressure necrosis in the soft, friable splenic tissue. A length of petroleum jelly gauze can be used in addition to help maintain free drainage.

Secondary splenectomy may be required for secondary hæmorrhage or multiple foci of infection.

Splenic neoplasms are not uncommon in children of the dark-skinned races. They *spread rapidly, cause great pain, fever, and local swelling with œdema on invasion of the* abdominal wall. Incision of such a swelling in mistake for an abscess will lead to a fungating necrotic sinus, or to a fatal hæmorrhage. If there is the slightest doubt about a splenic abscess it is better to open the abdomen away from the affected area and to explore: the characteristic white nodules of malignant growth will be seen.

WORMS AS A SOURCE OF SURGICAL EMERGENCIES

Ascariasis.—Nearly 100 per cent of all children admitted to hospital have worms, and 25 per cent of these are admitted for complaints directly due to these parasites. About 10 per cent of the children admitted are surgical cases, 8 per cent of intestinal obstruction and 1 per cent of peritonitis. The incidence among adult patients is much smaller.

Intestinal Obstruction due to Worms.—Because of the usual delay in seeking assistance most of the patients with this condition are admitted in a state of serious dehydration which accounts for the high mortality (about 10 per cent).

Treatment.—Emptying of the stomach and intestine by means of an indwelling aspiration tube, replacement of fluids intravenously or subcutaneously with hyaluronidase added, must commence at once. This accomplished, a full dose of 1 oz. (30 ml.) of piperazine is injected down the indwelling tube, followed by sufficient normal saline solution to empty the tube of the drug. About an hour later laparotomy is performed (*Fig.* 1522).

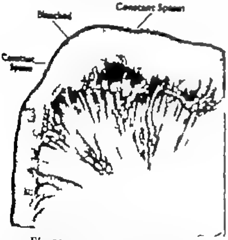

Fig. 1522.—A mass of worms causing obturation of the lumen, but from without constant spasm and blanching of the gut wall alone are visible.

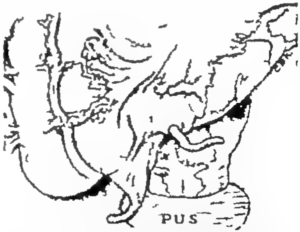

Fig. 1523.—Operative findings in the case of a male patient aged 22, diagnosed as acute appendicitis. As far as could be ascertained the ascaris had penetrated the normal intestinal wall.

Until about five years ago the practice was to incise the intestine and remove the mass of worms; the mortality of this procedure was about 30 per cent. With the advent of piperazine it has now become the practice gently to milk the mass of worms into the cæcum, and there to disperse them, thereby relieving the obstruction and exposing individual worms to the antihelminthic given already. During these manipulations a gentle milking action is employed, for the intestinal wall is very friable, especially in late cases. Of 8 patients with intestinal obstruction due to worms operated upon in one year, incision was only required in one instance, and that patient died.

Should resection be required e.g., for an accompanying gangrenous volvulus or intussusception, the operation should be completed, not by restoration of the continuity of the intestine but always by a double-barrelled enterostomy to be closed later

When intestinal obstruction is incomplete the administration of piperazine via the tube with fluid replacement is usually sufficient.

Peritonitis due to Worms is a very grave condition. In children only 1 in 5 recover Difficulty in diagnosis due to the absence of rigidity and sometimes the presence of peristaltic sounds is partially responsible for this high mortality The sites of perforation are the jejunum, ileum (*Fig* 1323), cæcum, or appendix. Through the perforation many worms escape into the peritoneal cavity but at laparotomy relatively few of these are recovered. Those left may go on living and should the patient survive, they are liable to cause further trouble A few patients come under observation with subacute signs only When the abdomen is opened, a condition is displayed that at first sight resembles tuberculous peritonitis. Biopsy of the infected peritoneum will show ova of *Ascaris*

In tropical practice tuberculous peritonitis is not an uncommon diagnosis in children with subacute abdominal complaints. How many of these are due to *Ascaris* ova?

Post-operative Complications in Ascaris-infested Patients are common. Knowledge of the infestation gained from routine pre-operative examination of the stools—a practice never to be omitted if possible, even in an emergency in the Tropics—will assist the surgeon in dealing with the copious vomiting these patients are prone to develop in the first twenty four hours after operation. These painful and alarming episodes usually terminate with the vomiting of a number of ascaris worms. Similarly obturation by a mass of worms may explain early post-operative signs of obstruction or a worm working its way through a suture line may account for peritonitis.

Acute diarrhœa after operation will rightly turn the surgeon's thoughts to that dangerous complication, fulminating colitis, but the episode may end abruptly with the passage of a number of round worms instead of the typical mass of discoloured blood and black slough expected.

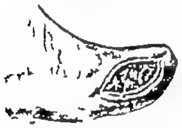

Fig 1324.—An appendix filled with *Enterobius vermicularis*.

I have seen a post-operative lung abscess following aspiration of an adult ascaris during recovery from a general anæsthetic.

Appendicitis caused by Worms.—Entry or impaction, of a number of ascaris adults into the appendix is a not uncommon cause of acute obstructive appendicitis in both children and adults. In children *Trichuris trichiura* (Whipworm), and *Enterobius vermicularis* (Pinworm), (*Fig* 1324) may cause symptoms and signs indistinguishable from those of appendicitis.

Other Abdominal Emergencies due to Worms.—In adults acute obstructive jaundice from lodgement of a worm in the common bile-duct is encountered from time to time A mesenteric cyst found to contain worms is also a cause of intestinal obstruction. Perforation of the œsophagus into the pleura, due to *Ascaris*, has been reported

Acute Abdominal Emergencies due to Ankylostome Infestation.—

A Hindu male aged 23, was admitted six hours after sudden onset of acute upper abdominal pain. He gave a history of previous dyspepsia with remissions. The temperature was 97° F (36 C.) and the pulse 120. Abdominal rigidity was so evident that the diagnosis of perforated peptic ulcer seemed assured As he came from an ankylostome district the possibility that the symptoms were due to this parasite was considered. His R.B.C. was 8,000,000 per cu mm. and the Hb 55 per cent. The stool revealed a comparatively small number of ankylostome ova. At a second clinical examination the rigidity was still the same Operation was decided upon. There was no perforation, but the duodenum was œdematous and of a dull red hue Three days after the operation he was given 4 ml. of tetrachlorethylene in 2 fluid oz. (60 ml.) of a saturated solution of magnesium sulphate with 1 ml. of oil of chenopodium shaken to an emulsion. This caused an immense number of worms to be passed per rectum, after which the symptoms abated.

On two other occasions patients with a profuse display of ova in the fæces were found on laparotomy to have perforated peptic ulcers. As a rule it is not particularly difficult to diagnose the abdominal crises of ankylostome infestation, provided it is known that the patient comes from a district where the disease is rife When rigidity as opposed to tenderness, is present and persists for over an hour it is imperative to explore

Ankylostome *infestation may simulate a bleeding peptic ulcer* Large *tarry stools* are passed but the stools contain such a mass of eggs that the cause of the bleeding is seldom in doubt In any case whether the bleeding arises from peptic ulceration or ankylostomiasis, the question of immediate operation does not arise, but blood transfusion is indicated, just as in a case of bleeding peptic ulcer a final decision as to correct procedure being arrived at when the patient has responded to blood replacement

AMŒBIC HEPATITIS AND ABSCESS

The tendency to *regard* amœbiasis as a tropical disease has resulted in a number of cases being overlooked in temperate zones ; amœbiasis occurs in all parts of the world Another important point is that even in the Tropics fully a quarter of the cases of liver abscess encountered are not amœbic in origin, but due to helminths, bacteria, or cholangitis Amœbic abscess occurs in children and is often overlooked with fatal consequences.

Pain and tenderness over the liver accompanied by fever bring many patients with amœbic hepatitis to the physician before abscess formation has occurred In this stage emetine gr 1 (65 mg) at once with gr 1 daily for twelve days ; or chloroquin 600 mg at once and 300 mg. daily for 21 days, will cure the condition at this stage which is probably *only in the nature of a reaction to toxin reaching the liver* from the intestinal lesions, rather than to actual lodgement of amœbæ causing diffuse hepatitis.

Fig 1523.—Typical chocolate pus aspirated from a liver abscess.

Principles in Treatment of an Amœbic Liver Abscess.—

1 Aspiration of the abscess (*Fig* 1523) should be attempted in every case It is not always easy to locate and in about 23–40 per cent of cases either the needle fails to enter the abscess cavity or if entered once, it is not located on subsequent occasions. In only 40 per cent of cases is the abscess solitary In about half the cases seen the abscess has ruptured, or does so shortly afterwards—two-thirds into the lung or pleura, one-third into the peritoneal cavity and an occasional one into the pericardium. It is to be borne in mind that of those patients suffering from amœbic abscess of the liver who die from this condition, over half succumb from abdominal complications of which bursting of the abscess into the peritoneal cavity is the most common—hence the importance of evacuating the pus before this catastrophe occurs. Secondarily infected abscess, and *abscess accessions*, should be treated by aspiration in the first instance Secondary infection can only be discovered by examining the pus removed at aspiration Undetected bacterial infection is particularly lethal.

2. Radiography (anteroposterior and lateral positions) reveals a shadow almost pathognomonic of liver abscess.

3. Emetine (10 mg per kg = ⅙ gr per 2 lb body weight) should be administered for three days before aspiration is carried out.

4. After aspiration a *full* course of emetine (650 mg per 68 kg = 10 gr per 150 lb) with suitable treatment for bowel amœbiasis must be given.

Recent comparison of the results of treatment by emetine with those of chloroquin suggests that while in their immediate effects there is little difference in *their more remote effects* chloroquin *is inferior in the eradication* of the parasites. The mortality among patients treated by chloroquin alone is greater than among those treated by emetine alone.

Aspiration.—Needle exploration should be carried out with a No. 13 exploring needle 6 in. (15 cm.) long. When an abscess is located, such liquefied material as can be aspirated is removed, and measured. *The needle is left in place, and a second needle employed to seek* a second abscess If one is found the same procedure is repeated, after which, if considered necessary a third abscess is sought in the same way Where an abscess has been located a No. 2 (1 mm. bore) polythene tube is passed through the needle into the abscess cavity and the needle withdrawn. A quantity of a preparation of streptokinase-streptodornase equal to the amount of pus aspirated is instilled into the abscess cavity The tube is then

sealed and fixed in place Twenty four hours later the now liquefied pus is aspirated through the tube and a further equivalent amount of streptokinase-streptodornase preparation instilled In this way the whole contents of the abscess cavity can be evacuated in about five to six days. The polythene tube or tubes, is then withdrawn.

Aspiration must be carried out with full aseptic precautions in an operating theatre Some form of closed technique will prevent secondary infection, if such is absent When secondary infection is present aspiration and, according to the organism present the instillation of 250 000 units of crystalline penicillin in the cavity together with full doses of systemic penicillin therapy will often overcome established secondary infection. Even if this plan fails, and drainage of the abscess becomes necessary as a result of these conservative measures the patient s general condition is usually benefited.

Technique —

When the abscess is located in the anterior portion of the liver the needle should be inserted *just* beneath the anterior costal margin 2 in. (5 cm.) from the middle line (*Fig* 1526 A).

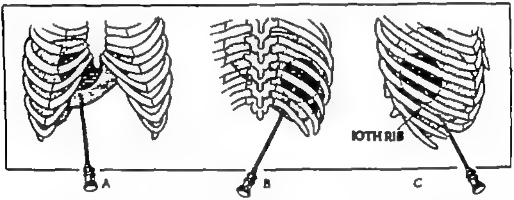

Fig 1526.—Aspiration of an amœbic hepatic abscess. A, In the anterior part of the liver B In the posterior part of the liver C, Located near the dome of the diaphragm.

When the abscess is located in the posterior portion of the liver with the patient prone and lying over a pillow the needle is directed superiorly and anteriorly from beneath the twelfth rib (*Fig* 1526 B).

When the abscess is located near the dome of the liver the needle should be inserted through the tenth intercostal space in the anterior axillary line (*Fig* 1526 C). A right sided abscess in this position is most frequent

Abscesses in difficult positions should be approached by an open operation and the polythene tube inserted under vision, the end being brought out through the incision, which is then closed. Treatment then proceeds as outlined above

Spontaneous Rupture —

When the pleural cavity is involved aspiration of the pleural collection of pus and of the content of the abscess cavity proper together with the use of penicillin and emetine therapy will usually enable the surgeon to avoid an open operation. If an empyema develops, the principles of treatment described on p 708 should be followed.

When the abscess has burst into the bronchus the aid of postural drainage should be invoked, in addition to the measures already indicated

Bursting into the peritoneal cavity calls for laparotomy Having aspirated and mopped up the pus in the peritoneal cavity a needle should be passed through the parietes into the liver and the liver abscess emptied of any remaining contents. While every effort should be made to avoid open drainage of the liver abscess, drainage of the peritoneal cavity is usually advisable

Open Drainage is now rarely called for Suitable technique is suggested on p. 11 and p. 719

EMERGENCIES ARISING FROM PRIMARY CARCINOMA OF THE LIVER

Patients with primary carcinoma of the liver sometimes present with acute abdominal symptoms due to (*a*) hæmorrhage into the carcinoma (*b*) rupture of the neoplasm through the liver capsule By the time the rapidly growing neoplasm has become thus complicated

nothing useful can be done to avert a fatal issue Packing can be resorted to as a temporary expedient

SOME ANO RECTAL EMERGENCIES

Alarming Rectal Hæmorrhage—Too easy acceptance of internal hæmorrhoids as the source of hæmorrhage has often led to disaster This is particularly true in the Tropics, for the majority of persons who have long resided in hot climates have at least some degree of varicosity of the inferior hæmorrhoidal plexus. Frequent causes of considerable bleeding are bacillary (*Fig* 1327), amœbic (*Fig* 1328) and malarial (subtertian) colitis. In certain

Fig. 1327 —Sigmoidoscopic appearance in bacillary dysentery (*After M A Arafa.*)

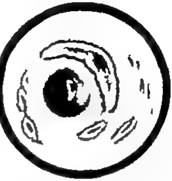

Fig 1328 —Sigmoidoscopic appearances showing ulceration in amœbic dysentery (*After M A Arafa.*)

parts of the world bilharzial (in the lower bowel) and ankylostome (in the upper bowel) infestations must also be taken into account Ankylostome infestation can cause copious bright red hæmorrhage but more often it is a source of melæna (*see* p 1009) Typhoid infections are more severe in the Tropics than in temperate climates, and alarming hæmorrhage may also be due to this cause (*see* p 402)

Hæmorrhage due to Dysenteric Infections.—The hæmorrhages are either severe and single, or repeated and small, the former being commoner in amœbic infections. A single large hæmorrhage may herald or accompany perforation of the colon

Fig 1329 —Ulcer with fistulous track 8 in. (20 cm.) to the rectum and containing amœbæ Healed with emetine and quinine irrigations of the track.

Treatment Important as it is to obtain accurate information as to the site of origin and cause of the bleeding treatment should be instituted at once and follows the usual precepts in the management of bleeding peptic ulcer Heroic efforts to reach the bleeding point are out of the question unless diagnostic sigmoidoscopy which should be performed, reveals it to be in the rectum, when after hot douching fulguration of the bleeding point with a cautery or a coagulating diathermy is excellent practice. An initial large single hæmorrhage usually responds to continuous-drip blood transfusion. Further hæmorrhages, especially if in diminishing amounts, should not be taken to imply that the bleeding is not coming under control they are to be expected. Small repeated hæmorrhages are more persistent; treatment seems only to control bleeding temporarily It is particularly in these cases that investigation to elucidate the source and cause of the hæmorrhage must not be delayed. While awaiting the result of these, and the commencement of specific therapy I have found the old fashioned starch and opium enema—2 oz. (60 G) of starch made up to a paste with warm water until it just flows easily through a rectal tube pulv opii being added in the proportion of 1 gr (0·06 G) to each ounce of the starch used—invaluable. The patient is

placed on his right side with the foot of the bed raised. A sigmoidoscope is passed as far as possible and through it a long wide-bore rubber tube is inserted into the colon. The warmed starch and opium paste is gravitated in fairly rapidly. The sigmoidoscope with the tube is withdrawn and the patient left in the position indicated for one hour before he is turned on to his back. As in all cases of hæmorrhage, a sedative is essential: a large dose of one of the barbiturates is to be preferred, because morphine depresses the respiratory centre. I have not found cæcostomy or ileostomy of any value in the treatment of hæmorrhage from the colon or rectum. On the other hand the pus and blood stool seen so frequently during intervals between small repeated hæmorrhages of the second type is an urgent indication for the operation of terminal ileostomy (*see* p. 526).

Perianal and Ischiorectal Abscesses and Fistulæ frequently have their origin in the rectum or even the lower left colon as a fistulous track from amœbic ulceration, or schistosomiasis of the colon, bladder or urethra. If attempts to heal the fistula by operation are doomed to failure in these cases, local and general specific therapy is usually successful (*Fig.* 1329).

ACUTE RETENTION OF URINE DUE TO SCHISTOSOMIASIS

This is a common emergency in countries where the disease is rife. There may or may not be a history of previous dysuria. Sometimes the penis and perineum feel indurated; more often rectal examination reveals a hard, ill-defined induration in the neighbourhood of the base of the bladder. However well it is lubricated, a urethral catheter does not pass easily into the bladder.

Treatment.—Frequently suprapubic drainage of the bladder is required. A cystoscope passed through a suprapubic stab incision in the exposed, but as yet unopened, bladder may reveal characteristic lesions. The urine must be examined for ova.

In a number of instances treatment with an antimony preparation (e.g., anthiomaline) causes the lesions to resolve, sometimes with restoration of free micturition. At others the resulting fibrosis of the prostate calls for transurethral resection to re-establish unimpeded micturition. Cases complicated by perineal fistulæ can only be cured by a block dissection of the fistulous tracks and that part of the urethra bearing the stricture.

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CHAPTER XCIII

APPENDIX

INTRAVENOUS FLUID THERAPY

Thrombophlebitis following Intravenous Infusions.—Clear evidence is provided by the Sub-committee[1] appointed to investigate the subject that the incidence of thrombophlebitis is much lower when plastic tubing is employed. *Intravenous infusions given through red rubber tubing, and lasting for more than 12 hours, predispose to thrombophlebitis.*

Modified Intravenous Drip Needle.—F. K. Boston[2] has had a hole bored in the shaft of the needle near its tip on the side away from the bevel (*Fig.* 1530) which obviates blockage of the needle, owing to its bevel coming up against the vein wall. The hole can be bored by any competent hospital-workshop technician.

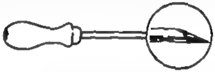

Fig. 1530.—*Intravenous needle with an accessory eyelet to prevent blockage.*

A Catheter for Exchange Transfusion in Newborn Infants.—A rounded-tip catheter[3] designed for insertion along the umbilical vein is now available. In addition to the suitable tip, its advantage over polythene tubing (F. L. Mollison and J. P. M. Tizard)[4] is its greater flexibility.

Supplying a High-calorie Non-protein Diet by the Intravenous Route.—W. H. Taylor[5] found that drip infusion into the inferior vena cava proved adequate for giving 50 per cent dextrose solution for periods as long as 11 days, but on necropsy in 3 patients so treated antemortem thrombosis of the saphenous and external iliac vein was found extending into the inferior vena cava in 2 patients, *despite the addition of heparin to the fluid entering the vein.* It was concluded that drip infusions into the inferior vena cava are potentially hazardous and should not be used if there is the smallest chance of maintaining a reasonable intake of fluid and at least 1000 calories a day either by mouth, a stomach tube, or through a smaller vein (*e.g.*, the saphenous or cephalic).

BLOOD TRANSFUSION

R. A. Zeitlin[6] has designed insulated containers[7] in which 2 (*Fig.* 1531) or 6 bottles of blood having been removed from the refrigerator at 4° C. (39° F.), can be kept for three hours without reaching a temperature higher than 8° C. (46° F.).

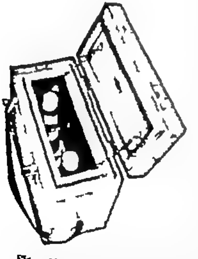

Fig. 1531.—Zeitlin's insulated container for storing blood after it has been removed from the refrigerator.

A useful guide to the blood requirements in multiple injuries is :—

	Blood Deficit
Single fractures	20 per cent (2 pints) (1136 ml.)
Two fractures	*20–40 per cent (2–4 pints) (1136–2272 ml.)*
Three fractures	40 per cent (4 pints) (2272 ml.)

M.R.C. Publications, No. 277[8]

Plastic Bags for Storing and Transfusing Blood have been issued by some Centres in the U.S.A. for a number of years, and a great stimulus to their more general use resulted from the very favourable report received from the Army Medical Services in the Korean War. The advantages claimed for plastic bags are less weight and smaller volume for storage, and particularly freedom from air embolism in pressure transfusion. H. A. F. Dudley and his colleagues[9] in Edinburgh have given these bags a trial. The only advantage they noted was the freedom from the danger of air embolism if pressure transfusion was considered necessary.

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[3] Edwards Surgical Supplies, 68, Mortimer Street, London, W. 1.
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[9] Dudley, H. A. F., et al., *Lancet*, 1956, 1, 294.

Massive Blood Transfusion for Severe Haemorrhage.—Despite much progress, the treatment of severe haemorrhage is still far from satisfactory. A relatively high proportion of patients are lost for various reasons. For instance, the death-rate from severe haemorrhage from a gastric or duodenal ulcer is still about 12 per cent. It is not unusual to observe, after an initial improvement, a gradual deterioration in the patient's condition in spite of continued transfusion. Often this is accompanied by a considerable rise in venous pressure, i.e., cardiac overload. As a result of experiments in more than 500 dogs, P. Firt and L. Hejhal,[1] of Prague, seem to have proved that almost invariably the overloading and failure of the heart during rapid intravenous transfusion is due not to the transfusion *per se* but to the amount of citrate solution given simultaneously. Citrate, even in small doses, produces vasoconstriction of the pulmonary vascular bed, and in larger doses depresses myocardial activity, both effects leading to cardiac overloading and failure. If 10 ml. of a 10 per cent solution of calcium gluconate is given before the transfusion, and a further 15 ml. intravenously after the first 100 ml. of blood has been gravitated, this suffices to neutralize the effects of the citrate for 100 ml. of blood. A further 10 ml. of 10 per cent calcium gluconate accompanies every additional 500 ml. of blood. Procaine, 0·6 ml. per kg. of body weight of a 0·25 per cent solution is given at the same time as the calcium gluconate before starting the transfusion. A continuous drip of a 0·25 per cent solution is then run in at the rate of 5 drops per 10 kg. per minute. The combined action of the calcium and the procaine neutralizes completely the baneful effect of the citrate.

The same principles apply also to retrograde arterial transfusion.

Fig. 1532.—Surface marking of the cephalic vein. (*Mr. L. G. Dolton.*)

Rapid Blood Transfusion through the Cephalic Vein.—L. G. Dolton has cannulized the cephalic vein (*Fig.* 1532) with the gold-plated cannula illustrated in *Fig.* 23 in over 100 cases in 12 months, and has been enabled to administer 1 pint (568 ml.) of blood in four minutes without any form of pressure. As a result of this experience he recommends the method strongly to those who are engaged in major surgery and are not blessed with many assistants. The only disadvantage has been that on 6 occasions the cephalic vein has been absent from its normal situation. Such patients have a small transverse subcutaneous vein across the front of the shoulder and he does not recommend exploration of the cephalic vein when such veins are present. After cannulization, he inserts a distal skin stitch which holds the cannula in its second loop, and a proximal skin stitch which, passing under the vein, is left long and untied until after the cannula has been removed.

Reactions after Transfusion.—Most hospitals report an incidence of 5 per cent pyrogenic reactions and 1 per cent allergic reactions (Annot., *Lancet*[3]).

Contaminants in Stored Blood.—The possibility that a patient may receive infected blood still remains one of the most serious and the least appreciated of the many dangers of blood transfusion. It is probable that this catastrophe is not as rare as the literature suggests, owing to understandable reluctance to publicize unfortunate accidents. M. G. McEntegart[4] gives details of 2 cases where during blood transfusion the patient became restless, developed rigors, and died. In one, at necropsy, the only macroscopic abnormal findings were submucosal petechiæ in the ileum and a haemorrhage into one adrenal gland. In both cases the suspected bottles of blood had been at room temperature for some hours. Both were found to be contaminated.

R. J. Drummond, Director of the Welsh Regional Blood Transfusion Service, suggests that a possible source of contamination is that when the blood-taking needle is withdrawn from the cap of the blood bottle a film of blood may track through the cap. From the film of fluid beneath the metal screw cap organisms could grow along the film of blood left in the track and so enter the bottle. After collection, the surface of the cap and the diaphragm should be wiped dry with sterile gauze.

Intravenous Preparations of Vitamin K_1, e.g., mephyton, are now available and should it be necessary to raise the prothrombin level rapidly, large doses (e.g., 100 mg.) can be given intravenously. Following such injections the prothrombin level has been known to rise to normal within 12 hours or less.

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[3] Annotation, *Ibid.*, 1955, 2, 180.
McEntegart, M. G., *Ibid.*, 1956, 2, 909.
[5] Drummond, R. J., *Ibid.*, 1956, 2, 1207.
Merck Sharp & Dohme Ltd., Hoddesdon, Herts.

Transfusion of Blood-platelets.—Some blood transfusion centres supply blood platelet concentrates for transfusion in cases of thrombocytopenic purpura. The benefit of the donor platelets is short-lived, often only a matter of a few hours, but in cases where cortisone or ACTH fails to bring about a remission, transfusion of platelets often stays the hæmorrhage sufficiently for the patient to be rendered fit to undergo urgent splenectomy with comparative safety (J. L. Pallis[1]).

Intraperitoneal Blood Transfusion in small children is praised both by K. H. Tallerman[2] and Lorna G. Macdougall.[3] The latter has given it an extended trial in Nairobi, where often conditions are unfavourable for blood transfusion into a vein. The blood must be cross-matched in the usual way. The intraperitoneal injection is made 1 in. (2.5 cm.) above the umbilicus after cleansing thoroughly the skin of the abdominal wall. The skin is grasped between the thumb and the forefinger of the left hand and traction is exerted on it while the needle is pushed slowly and firmly into the peritoneal cavity with the right hand. Immediately the needle has penetrated the skin the control clip on the giving set is opened fully, and as soon as the blood flows in a steady stream it can be assumed that the peritoneal cavity has been entered. The transfusion is completed within 10 to 20 minutes and the amount of blood transfused at one time is between 60 to 800 ml. By injecting cells labelled with radio-active chromium into the peritoneal cavity, Tallerman and his colleagues at the London Hospital have proved that the blood enters the peripheral circulation.

HÆMOPHILIA

Dental Extraction in Hæmophilia and Christmas Disease.—J. A. Orr and A. S. Douglas[4] report on 22 dental extractions in patients with hæmophilia or Christmas disease. The most common time for hæmorrhage to occur is the third day after extraction, but in one case it was as late as 17 days after the extraction. It is inadvisable to extract more than two teeth at a time. An acrylic-resin protective dental splint with a black gutta-percha inlay opposite the site of extraction was employed in all cases. Two pints (1140 ml.) of fresh frozen plasma were infused immediately before the extraction, and on the occurrence of bleeding, if this was severe enough. Orally administered antibiotic therapy was given for five days from the time of the operation.

C. Wishart et al. describe a similar routine in III hæmophilics. They have however by experience come to the conclusion that it is safer to extract up to six teeth at one session, rather than submit the patient who has to have a considerable dental clearance to multiple operations. With each succeeding operation the administration of AHG (antihæmophilic globulin) by plasma becomes increasingly less effective.

SHOCK

Noradrenaline in Shock due to Visceral Perforation.—Three patients with visceral perforation (two with perforated colonic diverticulitis and one with a perforated peptic ulcer) were in profound shock, and all responded only temporarily to intravenous infusion of dextran, followed by blood transfusion. After operation, all were placed upon noradrenaline infusion, with remarkable and sustained improvement. In reporting these cases, D. D. Davies[6] remarks that if the systolic blood-pressure remains below 70–80 mm. Hg for more than one to two hours, the chances of recovery of a seriously ill patient are small. Therefore in such cases every endeavour must be made to raise the systolic blood-pressure to over 90 mm. Hg as soon as possible. The paramount importance of adequate oxygenation in shocked patients is also stressed.

Skin Necrosis in Noradrenaline Therapy.—G. E. Heard[7] draws attention to the frequency with which skin necrosis follows noradrenaline fluid therapy. The best method of administering noradrenaline is through a polythene tube passed well up so that its tip lies in a vein of much greater diameter than the one through which the tubing is inserted. The early administration by multiple subcutaneous injections of piperoxane hydrochloride in a dilution of 5 mg. in 20 ml. of normal saline solution is often followed by a quick return of the skin in the ischæmic area to normality. The method is free from danger. Piperoxane elevates the blood-pressure only in the presence of a phæochromocytoma. (L. Pelner;[8] P. Dutton, and R. E. Forgie.[9])

The Treatment of Shock by Intravenous Procaine.—A. Brodetti[10] reports most favourably on the treatment of shock by intravenous procaine. The use of intravenous procaine reduces, or obviates, the necessity for giving morphine. Some striking improvements in the blood pressure (60 rising to 120) were observed following the injection, but the beneficial effect was maintained

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[9] Dutton, P., and Forgie, R. E., *Brit. med. J.*, 1958, 1, 644.
[10] Brodetti, A., *Gior. ital. Chir.*, 1951, 7, 551.

only for about half-an-hour this, however, in many instances gives time for the introduction of a plasma volume-expander or blood to prevent relapse. Procaine is rapidly destroyed in the circulation, so there is no danger of an accumulative effect Brodetti injects 10-20 ml. of a 1 per cent solution of procaine slowly taking at least two minutes over each ml. A. Berner[1] places 2 ml. of a 2 per cent solution of procaine in a litre flask of intravenous fluid. He does not recommend more than 2000 ml. of this mixture being given. Intravenous procaine should not be given to patients who are in a state of malnutrition, or to those with liver disease and succinyl-choline should never be administered as a relaxant in the presence of intravenous procaine All these factors interfere with the chemical breakdown of procaine in the body (D Smart[2]).

Lightning Shock.—The brain seems to be the most sensitive organ to the effects of lightning and electric shock. For this reason artificial respiration should be given to those apparently dead from lightning or electric shock. However as soon as possible a physical examination is also necessary since other potential fatal lesions, such as fracture of the skull, may result from the patient being hurled to the ground or on to another hard object by the force of the current. It is surprising that those who survive being struck by lightning do not often suffer permanent or striking disability Minor sequelæ such as headache and paræsthesia, are commonplace

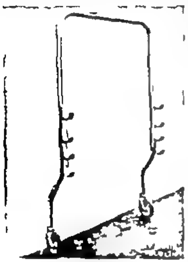

Fig 1533.—The Meath Hospital bed elevator

The Meath Hospital Bed Elevator[4] (*Fig* 1533) is made of tubular steel and is fitted with ball-bearing castors. A nurse can easily raise single handed either the foot or the head of the bed to the desired height, as directed. It fits all standard hospital beds.

CARDIAC RESUSCITATION

Cerebral Œdema after Cardiac Resuscitation.—Sucrose not being available J. C. A. Raison[5] injected 25 ml. of 50 per cent dextrose. The dosage was repeated hourly for 5 hours, and slow but steady improvement took place. Sucrose is much to be preferred because it does not produce a secondary rise of pressure of the cerebrospinal fluid, as does dextrose. In addition, up to 50 per cent of the dextrose given may be stored in the body tissues, thus reducing its dehydrating value on the brain. Also, it can cause tissue œdema when water is given later In a second case sucrose was employed, orders having been given for this solution to be always available in the operating theatre Raison also comments on the inestimable value of tracheostomy in these cases of cerebral œdema. It enables the patient to be nursed in a sitting position while still unconscious, and remarkable improvement followed the adoption of this position, which probably aids cerebral dehydration.

Intracardiac Blood Transfusion for Cardiac Arrest.—J I Lawson[6] reports a successful case The patient was a man of 78 years of age who became pulseless after a spinal anæsthetic. After the usual resuscitative measures failed to improve matters, subdiaphragmatic cardiac massage was performed without avail. A long wide-bore needle was then inserted into the heart through the fourth intercostal space 2½ in. (6 25 cm.) from the middle line and 500 ml. of blood was pumped into the left ventricle in three minutes. The heart commenced to beat vigorously and progress was maintained.

ACUTE NON-SPECIFIC INFECTIONS

Antibiotic resistant Organisms.—Of 1840 strains of *Str* pyogenes, all proved sensitive to penicillin (E. J L. Lowbury). However in mixed staphylococcal and streptococcal infections, staphylococcal penicillinase produced by penicillin-resistant staphylococci, can prevent successful penicillin therapy for streptococcal infections (J D A. Gray). Occasionally streptococci are isolated which have not only broken through the penicillin barrier but are moderately resistant to both aureomycin and oxytetracycline For these, erythromycin (which should not be used if any other antibiotic is effective) has until recently proved both non-toxic to the patient and lethal to the said streptococci. Now erythromycin resistant organisms have emerged (E. J L. Lowbury).

Steroids in Septicæmia.—Steroids, plus the *correct* antibiotic led to the resolution of some cases of septicæmia from a focus in the lungs or beneath the diaphragm by removing, as it were the

[1] Berner, A., *Helvet chir Acta*, 1949 16, 872.
[2] Smart D., personal communication.
Annotation *Brit. med. J.*, 1957 2, 1168
[4] Fannin & Co. Ltd., 41 Grafton Street Dublin.
[5] Raison J C A., *Lancet*, 1957 2, 984
[6] Lawson J I., *Brit J Anæsth.*, 1956, 28, 336.
Lowbury E. J L., personal communication.
[7] Gray J D A., *Lancet* 1956, 2, 132.
Lowbury E. J L., *Proc R. Soc Med.*, 1958 (in the press).

barrier and allowing the antibiotic access to the infected focus. This treatment is not without risk, but clinical circumstances may on occasion, justify its trial (W F Walker[1])

Staphylococcal Septicæmia (Penicillin-Resistant) is becoming more common in neonates (H. Wallis[2]), and, as a complication of some other disease in adults. According to D Rogers[3] the staphylococcus appears to have displaced the pneumococcus as the invader in terminal illness.

Abscess of the Breast.—Masking of signs of inflammation by antibiotics not infrequently leads to undue delay in opening a breast abscess (*Fig* 1534), with a resulting excessive destruction of mammary tissue, sometimes amounting to a functional mastectomy Now and then the excessive fibrosis thus induced and the absence of tenderness has caused the diagnosis to be revised in favour of carcinoma. *Another* disadvantage of undue delay is the deposition of a wealth of exuberant granulation tissue on the walls of the abscess this has brought about profuse hæmorrhage when the abscess is incised. To obviate these untoward possibilities, when in doubt as to the presence of pus, the indurated mass should be explored with a needle and syringe under general anæsthesia, and incised if pus is found

Fig 1534 —Breast riddled with abscesses. No pain or other constitutional symptoms. A fool s paradise created by much penicillin and little clinical acumen. The left breast *had been removed for fibro-adenosis six years* previously

Treatment of Pseudomembranous (Post-operative) Enterocolitis (Staphylococcal Enterocolitis).—There has been a disconcerting increase in the incidence of this alarming, and frequently *fatal* variety of enterocolitis, an increase that coincides with the advent of broad-spectrum antibiotics. Nonetheless, post-operative pseudomembranous enterocolitis was known in the pre-antibiotic era; thus the oral administration of antibiotics cannot be held entirely responsible yet there is little doubt that it accounts for the increased frequency of the condition.

Ætiology.—Prevailing opinion indicates that the initial, and occasionally the only cause is intense vasoconstriction of intestinal blood-vessels consequent *upon shock; this vasoconstriction imperils* the vitality of the intestinal mucous membrane to such an extent that some of its cells perish. The other cause (which in some instances operates single-handed) is suppression of normal intestinal flora by antibiotics resulting in a preponderance of one or more species that assumes the role of a pathogen. Resistant staphylococci overwhelmingly predominate, but on occasions *B proteus* cannot be exonerated.

Pathology.—In the most severe form, areas of necrotic mucous membrane are shed, or they remain as a pseudomembrane attached to the deeper layers of the intestinal wall. The lower ileum is chiefly affected.

Clinical Features. —The diarrhœa is often cholera-like and commences abruptly or in patients undergoing gastro-intestinal aspiration, the aspirate becomes foul and alarmingly excessive. Collapse in the peripheral circulation follows so rapidly that without effective treatment death may occur within 72 hours. Advanced age lowered resistance, and malnutrition each can play an important part.

Treatment.—

First the broad-spectrum antibiotic having been discontinued, no effort is spared to restore the blood-pressure and the fluid and electrolytic balance. The amount of fluid loss in these cases is prodigious (10–20 l. per day) and this must be replaced. The administration of noradrenaline in adequate doses to maintain blood-pressure is important. Erythromycin is the most effective drug against staphylococcus, although there is a rapid increase in the number of strains resistant even to this antibiotic. Bacitracin can also be used. When the organism is isolated and its sensitivity investigated, the bacteriologist s report should influence the antibiotic given.

Secondly the great loss of protein requires blood transfusion. The caloric requirements can be met in part by intravenous 10 per cent dextrose. The danger of disseminating the infection precludes the use of ACTH in the early phases, but it can be administered with safety and advantage when culture of the stools indicates that infection has been controlled. The oral administration of a preparation containing lactobacillus helps in the restoration of the normal intestinal flora (Hamilton Bailey and McNeill Love[4])

[1] WALKER, W F., personal communication.
[2] WALLIS, H., personal communication.
[3] ROGERS, D., *Ann. intern. Med.* 1956, 45, 748.
[4] BAILEY HAMILTON and LOVE, R. J McNEILL, *A Short Practice of Surgery* 11th ed., 1958. London: H. K. Lewis.

Post-operative Wound Infection.—At the Edinburgh Royal Infirmary in a three-months' survey of the operation wounds of 672 patients, it was found that in 0·8 per cent serious wound infection occurred and there was an additional 6·8 per cent of trivial infection. In no instance was death attributable to infection of the wound. J. S. Jeffrey and S. A. Sclaroff[1] came to the conclusion that the great majority of the infections originated in the operating theatre, and only a minority were due to cross-infection in the wards.

ACUTE SPECIFIC INFECTIONS

Tetanus.—The urgent problem of established tetanus is to control the convulsions. A R. A. Lewis et al.[2] state, in spite of the introduction of potent antitoxin, antibiotics, various relaxants, general anaesthesia, tracheostomy and intermittent positive-pressure respiration in the management of tetanus, the problem of preventing death in severe cases is still unsolved.

R. Batten[3] reviews some of the modern methods of treating severe tetanus thus:—

Central depressants are likely to depress respiration, but comparatively large series of cases have been reported without a death.

Relaxants advocated by so many workers in recent years, are likely to be needed in such large doses that the diaphragm also is paralysed. This, in turn, demands tracheostomy and positive-pressure respiration.

Tracheostomy diminishes spasms and facilitates the sucking-out of secretions. Nevertheless, pulmonary complications are not notably reduced. Continuous attendance by a doctor is almost essential and a great strain is thrown on the nursing staff.

Antitetanic serum. The quantity, route, and timing of antitetanic serum in published cases have been so varied that its value seems uncertain. Anaphylactic deaths from antitetanic serum are not very rare.

H. C. A. Lassen and E. Hendricksen[4] reported that the protracted administration of 50 per cent nitrous oxide and 50 per cent oxygen to patients with severe tetanus may lead to fatal aplastic anaemia. The noxious effect on the bone-marrow is caused by the nitrous oxide, and not by the oxygen.

Other Newer Methods of Treatment are.—

Chlorpromazine: R. S. Packard et al.[5] report two patients—a girl aged 12 and a boy aged 14 years—who were treated with large doses of chlorpromazine amounting to between 400 and 600 mg. daily together with amylobarbitone, both given intravenously in the following way: a polythene catheter was introduced into the long saphenous vein and advanced into the inferior vena cava. All nutrition and drugs were administered by this route. The successive daily doses of chlorpromazine and sodium amylobarbitone in mg. were:—

Day:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Chlorpromazine	200	500	450	350	830	930	650	625	550	450	225	150	50	[illegible]
Sodium amylobarbitone	500	500	0	800	125	100	500	0	300	0	800	200	100	0

Hydrocortisone in Severe Tetanus.—R. A. Lewis et al. speak most highly of the parenteral administration of hydrocortisone 50 mg. added to an intravenous infusion of dextrose-saline administered over about 4 hours, which can be repeated once if necessary. Intramuscular injections of hydrocortisone were commenced at the same time, 25–50 mg. being administered every six hours, and the dose gradually decreased. If hormone is still required after ten days, oral cortisone is substituted to conserve the supply of hydrocortisone. Injected cortisone should be avoided as it aggravates spasms. The only other drugs employed were moderate doses of paraldehyde and antibiotics for the concomitant wound infection. After successful application of corticotrophin in 5 severe cases, these authors are full of praise for this form of treatment.

If there is dysphagia or total trismus, parenteral hydrocortisone is the best choice but its action is inferior to that of cortisone by mouth.

Prognosis in Tetanus.—The length of the incubation period seems clearly to be related to the severity of the disease—the shorter the incubation period the worse the prognosis—but in the case of a patient admitted to the Birmingham Accident Hospital where the incubation period was only 56 hours, recovery followed, showing that a very short incubation period is not necessarily of grave import (R. Batten[3]).

[1] Jeffrey, J. S., and Sclaroff, S. A., *Lancet*, 1958, 1, 863.
[2] Lewis, R. A., et al., *Ibid.*, 1958, 1, 506.
[3] Batten, R., *Ibid.*, 1956, 1, 231.
[4] Lassen, H. C. A., and Hendricksen, E., *Ibid.*, 1956, 1, 963.
[5] Packard, R. S., et al., *Brit. med. J.*, 1958, 1, 16.
[6] Lewis, R. A., et al., *Lancet*, 1958, 1, 506.

Tetanus in Nigeria.—Tetanus is the third most common cause of admission to the adult medical wards of University College Hospital, Ibadan, Nigeria. D D Johnstone[1] describes the treatment employed for this condition at this Centre A special nurse is detailed for each patient. Drinking is made easier for those with trismus by the use of straws. Penicillin is given intramuscularly until 24 hours after the cessation of spasms. Latterly the use of antitetanic serum has been discontinued. Various methods of controlling the spasms have been tried; latterly chlorpromazine and muscle relaxants have been the agents most favoured by the medical staff.

In spite of these modern methods and careful nursing owing to the advanced state of the disease of many of the patients at the time of admission, the mortality is still very high The report on the last 100 cases (1955 and part of 1956) shows a death-rate of 58 per cent

Tetanus after Operation.—The power of tetanus to strike a hospital with sudden ferocity is reported from time to time. At the North Staffordshire Royal Infirmary Stoke-on Trent[2] 5 patients were attacked, and 2 died. More often than not, in spite of a most complete investigation, the source of the infection remains doubtful. Previous epidemics in various parts of the country have been attributed to dust entering the operating theatre, to catgut to the use of other imperfectly sterilized material, and to infected hair used in the binding of plaster when the walls of the operating theatre were repaired.

Anthrax from Bone-meal Fertilizer.—Six cases of anthrax occurring in Dundee and district are described. It was proved that imported bone meal from the Far East was the source of infection in 3 cases, and it was highly probable that the remaining 3 were infected from the same source (W M Jamieson and D M. Green[3]).

Gas Gangrene.—The prognosis in cases of infection by gas-forming organisms depends on its *early recognition, and two signs are of paramount importance: (1) The presence of a rising pulse-*rate in a patient who otherwise looks surprisingly well, and (2) The characteristic odour which once encountered, is never forgotten It resembles the smell of decaying apples, and is slightly sweetish. Examination of the wound shows a surrounding area of red, brawny swelling; the area is sometimes some distance away from the wound. The most common sites for gas gangrene are the adductor region of the thigh, and the buttocks. In the upper limb the subscapular region is the most frequent (B. McMurray[4]) Crepitus beneath the skin is not common, and in the diagnosis of otherwise suspicious cases the absence of this sign must never negative the diagnosis of gas gangrene. It is not unknown for gas gangrene to commence in a part of the body that has not been wounded the organisms having been carried thither by embolic spread.

Cat-scratch Disease is thought to be due to a virus of the psittacosis-lymphogranuloma venereum group. The cat sharpens its claws on tree-trunks and regularly licking its paws, transfers the virus from claws to mouth, thus explaining how the disease can follow a scratch or a bite. The virus is widely distributed on tree-trunks and other forms of vegetable life

More often than not, cat-scratch disease presents as a well-defined clinical entity As a rule the scratch or bite of the cat persists until signs of the disease are evident. These consist of pyrexia and tender enlargement of the regional lymph-nodes, which tend to break down and discharge sterile pus. Rose's intradermal test confirms the diagnosis, viz. 0·1 ml. of cat-scratch fever antigen Colindale is injected intradermally The antigen is a relatively crude product made from a suppurating lymph-node of an infected patient and uniform results need not necessarily be expected (R Ll. Lyon[5]). The results of therapy are difficult to assess, as the disease is a self limiting one. Chloramphenicol and oxytetracycline are thought to be of some benefit

The disease is as common in Great Britain as it is abroad (T A Brand and K. C. Finkel[6]).

E. Hinden gives an account of 5 cases. In 2 the site of the disease was the axilla, in 2 the groin. One patient presented with conjunctivitis and pre-auricular adenitis.

In a patient who developed supratrochlear adenitis as a result of cat-scratch disease, pneumonia, which was presumed to be the result of viremia, developed (G C. Sheldon and H. Smellie[8]).

SNAKE-BITES

Only 7 fatal cases of viper bites have occurred in the United Kingdom during the last 50 years (P Manson-Bahr[9]). It is therefore difficult for those residing in a temperate climate to realize the magnitude of the menace of snake-bites. In India and Pakistan it is estimated that the annual death-rate from snake-bites is between 20 000 and 38,000 (W B. Roantree[10]).

1 Johnstone, D D., *Brit. med. J.*, 1958 1 12.
2 Annotation *Lancet* 1957 1, 575
3 Jamieson W M., and Green D M., *Lancet*, 1958 1, 560.
4 McMurray B., *S Afr med. J.*, 1940 22, 207
5 Lyon R. Ll., *Lancet*, 1956, 2, 535.
6 Brand, T A., and Finkel, K. C., *Brit. med J.*, 1956, 1, 88.
7 Hinden E., *Ibid.*, 1957 2, 444.
8 Sheldon G. C., and Smellie, H., *Ibid.* 1957 2, 446.
9 Manson Bahr, Sir Philip *Ibid.*, 1957 2, 468.
10 Roantree, W B., *Ibid.*, 1957 2, 236.

The first-aid treatment of snake-bite has undergone complete revision. A tourniquet, incision, and laceration of the wound together with suction, have been discountenanced in countries such as India and Brazil where snake-bites are commonly serious or fatal. At the Liverpool School of Medicine these measures are pronounced to be utterly useless (R. Burkitt[1]), and gangrene of an extremity following a snake-bite is more likely due to a misapplied tourniquet than to the lesion.

Sir Philip Manson-Bahr[1] draws attention to the modern first-aid treatment for Russell viper bites now used in India with apparent success. This is so simple that it should be known to every practitioner. It is harmless, and can now be said to be sanctioned by usage in thousands of cases. The area of the bite is smeared copiously with carbolic soap (*e.g.*, Lifebuoy soap) and as soon as possible a 5 per cent solution of this soap is injected into the site of the bite and into the surrounding subcutaneous tissue. This delays absorption of the venom. The treatment has received the sanction of so great an authority as M. L. Ahuja.[2]

If effective antivenene is available the sooner it is given the more likely will it help the patient. In Malayan hospitals a snake-bite treatment box with polyspecific antivenene cortisone adrenaline and sterile syringes is immediately available in the dispensary (H. A. Reid.[2])

THE ABDOMINAL WALL

Progressive Bacterial Synergistic Gangrene of the Abdominal Wall.—Four months before admission, a coloured woman aged 82 was operated upon for fibromyomata of the uterus. Suppuration in the abdominal wall ensued. Gradually the surrounding skin became gangrenous, and the process spread. Local applications of various kinds and the systemic use of the usual antibiotics were of no avail. In the course of two months the lesion involved almost all of the lower half of the abdominal wall, and spread down the outer aspects of the thigh (*Fig.* 1535). At this stage the patient was admitted to the Presbyterian Hospital, New York, under the care of Dr F. L. Meleney. Bacitracin was given intramuscularly in doses of 200,000 units every six hours, and the infected area was covered with gauze wet with bacitracin solution in a concentration of 1000 units per ml. The moist dressing was covered with a double layer of zinc oxide ointment on gauze, to prevent drying.

Fig. 1535.—Progressive bacterial synergistic gangrene of the abdominal wall and thighs occurring in a coloured woman aged 82. (*Dr F. L. Meleney.*)

At the termination of 48 hours it was obvious that the progress of the disease had been arrested. Soon the gangrenous area on the right side of the abdomen separated, and could be lifted off as one piece. The systemic administration of bacitracin was terminated on the twenty-ninth day but the local application was continued. Finally epithelialization was hastened by the application of 2 per cent oxyquinoline in 5 per cent scarlet red ointment applied on gauze after bathing the granulations with bacitracin solution. The patient has remained in good health.

Disruption of a Laparotomy Wound (*syn.* **Burst Abdomen**).—A. Standeven[3] records that this complication ensued in 28 of 2030 laparotomies performed at the Royal Sussex County Hospital, Brighton, giving an incidence of 1·4 per cent. The cases fell into two groups—an early group, in which the disruption took place during the first seven days, and a late group, in which the wound burst asunder on the eighth or subsequent days. The former was the more frequent (18 cases). Standeven rightly has come to the conclusion that in many of these early cases the damage is done while the patient is still in the operating theatre or before the patient regains consciousness in the ward. It occurs during the removal of an endotracheal tube or the aspiration of mucus through the tube when the plane of deep anæsthesia is lightening. These manœuvres bring on a most violent cough while the patient is still unconscious, and the explosive cough with the great rise in intra-abdominal pressure cause the deep sutures to break. Often the fact that the wound has burst asunder is not noticed until a few days later when some of the skin sutures give way. In the late group every patient showed either a low serum-protein level or a hæmatoma

[1] Burkitt, R., *Brit. med. J.*, 1937, 2, 150.
Manson-Bahr, Sir Philip, *Ibid.*, 1937, 2, 488.
[2] Ahuja, M. L., and Singh, G., in *Venoms* (ed. E. E. Buckley and N. Porges), 1956. Washington.
Reid, H. A., *Brit. med. J.*, 1937, 2, 76.
[3] Meleney, F. L., personal communication.
Standeven, A., *Lancet*, 1955, 1, 533.

infection of the wound, or both. Five of the 28 patients died: 1 from paralytic ileus 4 from pulmonary complications. A. Walsh[1] reminds us that bursting of the abdomen is always heralded by an ooze of serous fluid that is often blood-stained.

Ruptured Umbilical Hernia.—H de Glanville[2] reports an example of this rare emergency in an African woman aged 30 seven months pregnant. A piece of greater omentum was protruding from a large ruptured umbilical hernia. A Mayo repair was carried out under general anæsthesia Her progress was uneventful and she was delivered normally at home two months later

G. E. Parker[3] reports a similar case in an elderly man who had had an umbilical hernia for over thirty years. After a bout of coughing the hernia ruptured, and many feet of small intestine and the sigmoid colon protruded. This patient also made a good recovery after operation.

PERITONITIS

The Role of Bacteroides in Peritonitis and in Infections of the Abdominal Wall.—The bacteroides (syn. *Fusobacterium*), which are Gram-negative, anaerobic, non-sporing bacilli, require for their identification not only anaerobic apparatus, but an adequate carbon-dioxide tension in that apparatus, and culture for more than 48 hours (W A. Gillespie and J Guy;[4] A. A. Gunn[5]). No doubt it is for these reasons that this group of organisms has escaped the notice of bacteriologists and surgeons as causative organisms in peritonitis, notably that due to appendicitis or diverticulitis.

In normal circumstances the bacteroides sometimes outnumber *Esch. coli* of the fæces by more than a hundredfold (W W C. Topley and G S. Wilson[6]). Two members of the genus are pathogens and are mainly responsible (usually in symbiosis with other organisms) for the lesions in question. They are:—

1 *Bacteroides funduliformis* (the causative organism of calf diphtheria), a coccobacillus 1–4 microns in length with a terminal enlargement (*Fig.* 1536), is the more virulent, and in some instances is the cause, not only of peritonitis, but of septicæmia and death (A. A. Gunn;[5] J M. Alston[7]). The diagnosis of infection by this organism is suggested by the peculiar odour like that of over-ripe camembert cheese (J M Alston).

2. *Bacteroides fragilis* a small bacillus which usually produces more localized infections.

Fig 1536.—Microphotograph showing *Bacteroides funduliformis* (*Dr Andrew F MacCabe*)

The part played by the bacteroides in abdominal suppurative lesions is arrestingly presented by Gillespie and Guy[4] in their bacteriological study of 111 cases of peritonitis, including discharging abdominal wounds, occurring at the Royal Infirmary Bristol. In this series the organisms isolated were as follows —

Bacteroides	67
Coliform bacilli	60
Anaerobic streptococci	43
Aerobic streptococci	40
Gram-negative bacilli other than coliforms	15
Staphylococcus aureus	10
Micrococci and *Staphylococcus albus*	10
Clostridia	7

Of cardinal importance is the knowledge that bacteroides are completely resistant to the antibiotics so widely employed in the treatment of peritonitis, to wit, penicillin and streptomycin (L. P Garrod[8]). Fortunately at present they are all sensitive to the tetracycline group. Surgeons and bacteriologists should combine to seek bacteroides in every case of peritonitis, intra-abdominal abscess, and discharging abdominal sinus.

Hydrocortisone in the Treatment of Grave Diffuse Peritonitis.—While the combined use of antibiotics and adrenocortical extracts has proved life-saving in almost moribund patients with acute pancreatitis, Waterhouse Friderichsen syndrome, or pseudomembranous enterocolitis, it is of fundamental importance to refrain from giving this combined therapy in peritonitis except in desperate cases with very clear indications, and then only with an unwavering proviso—viz. *that an urgent operation will be performed if and when the patient is fit to undergo it.* Under these conditions cortisone can be used to borrow time in which to replace fluid and electrolytes, and administer

[1] Walsh, A., *Lancet*, 1933 1 678.
[2] de Glanville, H., *Ibid.* 1933 2, 1321
[3] Parker, G E., *Ibid.*, 1956 1, 107
[4] Gillespie, W A., and Guy J., *Ibid.*, 1956, 1, 1039
[5] Gunn A. A., *J R Coll. Surg Edin.*, 1956, 2, 41; and *Arch. Dis. Childh.*, 1957 32, 523.
[6] Topley W W C., and Wilson G S., *Principles of Bacteriology* 4th ed. 1955 London: Arnold
[7] Alston J M., *Brit. med. J* 1955, 2, 1524.
[8] Garrod, L. P., *Ibid.*, 1955, 2, 1539

antibiotics. The adrenocorticotropic and adrenocorticosteroid hormones are known to exert an anti-inflammatory effect and also a toxic-blocking action (G. C. Heaigor et al.[1]). The dosage is similar to that advised in ultra-acute pancreatitis on page 838.

Not infrequently so great is the improvement that the danger lies in postponing operation, with the result that as soon as the hydrocortisone is withdrawn, the patient relapses into a condition worse than that before the steroid was commenced. Therefore this form of therapy should never be employed in peritonitis unless it has been decided to operate. Cortisone prevents the *walling-off of inflammatory processes by adhesions.*

As ACTH and cortisone tend to accelerate the breakdown of protein, and to cause depletion of potassium and chloride and retention of sodium, electrolytic balance must be maintained with extreme care potassium supplementation frequently being necessary (L. W. Kinsell[2]).

Fig 1537.—Meconium peritonitis. Free air and fluid in the peritoneal cavity. Intra-abdominal calcification ( ). Microcolon also shown by a barium enema. (*Dr Jack Lester.*)

For an unknown reason, in some cases cortisone renders antibiotics impotent and seems to exalt the virulence of the infecting organism. L. V. Phillips et al. report 4 cases of fatal septicæmia following the exhibition of this combination of drugs in patients suffering from chronic skin lesions such as exfoliative dermatitis.

Meconium Peritonitis.—The characteristic signs usually commence immediately after birth. They are vomiting, abdominal distension, and failure to discharge meconium. The abdomen becomes increasingly distended. The diagnosis is confirmed by radiological examination. Free air often in large amounts, is found in the peritoneal cavity as also abundant abdominal fluid (*J. Lester*[4]). *The most characteristic* feature is areas of intra-abdominal calcification which occur in the cornified epithelial cells from the extravasated meconium (*Fig.* 1537).

Acute Chylous Peritonitis.—F. J. Wright[5] suggests that all cases are due to blockage of the main lymph-ducts by an inflammatory reaction around adult filaria (*Wuchereria bancrofti*).

Diffuse Peritonitis due to Perforated Carcinoma of the Colon.—Three per cent of cases of diffuse peritonitis are secondary to acute perforation of the colon resulting from carcinoma. The mortality is very high (over 80 per cent). (W. L. Merabeimer and E. M. Miller[6])

Perforation of a Typhoid Ulcer.—During recent years R. L. Huckstep has treated over 1000 cases of typhoid. In cases of perforation of a typhoid ulcer he has found that non-operative treatment similar to the Ochsner-Sherren treatment of late acute appendicitis, together with the administration of larger doses of chloromycetin orally give results far better than those obtained by laparotomy closure of the perforation, and drainage of the peritoneal cavity.

Acute Primary Mesenteric Abscess.—H. A. F. Dudley and I. F. MacLaren report 2 cases of acute mesenteric abscess. One occurred in a male aged 42, who was admitted with signs of *incomplete obstruction of the small intestine. The other a male aged 82* was diagnosed provisionally as an appendix abscess. On laparotomy in neither was a demonstrable focus found. In both the abscess was drained, and in each instance the patient recovered.

Periodic Peritonitis is characterized by abdominal pain and tenderness, mild pyrexia, polymorphonuclear leucocytosis, and occasionally pain in the thorax and joints. The duration of an attack is 24 to 72 hours, when it is followed by complete remission, but exacerbations recur at regular intervals. Most of the patients have undergone appendicectomy in childhood. The disease often familial, is limited principally to Arabs, Armenians, and Jews; other peoples occasionally are affected. At laparotomy which may be necessary to exclude other causes, the peritoneum—particularly in the vicinity of the spleen and the gall bladder—is inflamed. There is no evidence that the interior of these organs is abnormal.

Differential Diagnosis.—Patients with abdominal epilepsy do not have physical signs or pyrexia, and their attacks are usually controlled by anticonvulsive medication.

The aetiology of periodic peritonitis is unknown, and no form of treatment has been found to be of the slightest avail (G. S. Sturtz and E. C. Burke[9]).

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[1] HENCHAR, G. C., et al., *Arch. Surg., Chicago,* 1956, 73, 804.
KINSELL, L. W., *J. Int. Coll. Surg.,* 1954, 21, 230.
[3] PHILLIPS, L. V., et al., *Antibiotic Med.,* 1955, 1, 231.
LESTER, J., *Acta radiol., Stockh.,* 1956, 46, 030.
[5] WRIGHT, F. J., *Lancet,* 1950, 1, 160.
MERSHEIMER, W. L., and MILLER, E. M., *Surg. Gynec. Obstet.,* 1954, 99, 439.
HUCKSTEP, R. L., Thesis for the M.D. Cambridge, 1957.
DUDLEY, H. A. F., and MACLAREN, I. F., *Lancet,* 1956, 2, 1182.
STURTZ, G. S., and BURKE, E. C., *Amer. J. Dis. Child.,* 1956, 92, 890.

Pyocele of a Hernial Sac.—K. Cronin[1] and H. Ellis, Surgical Registrars at the Radcliffe Infirmary Oxford, have encountered 3 patients with generalized abdominal pain and vomiting who also had an irreducible tender external hernia (two inguinal and one umbilical). In each instance operation showed that the patient was suffering from diffuse peritonitis with a localized collection of pus in the hernial sac. In two further cases a localized collection of pus in a hernial sac requiring drainage occurred in patients recovering from the acute episode of generalized peritonitis.

OTHER METHODS OF DRAINING THE PERITONEAL CAVITY

Fig. 1538.—The India rubber suction drainage tube

The Chaffin Rubber Suction Drainage Tube[2] (*Fig. 1538*) was invented by Dr R. C. Chaffin[3] of Los Angeles. Within the abdomen the tails attract fluid to the bottom of the well in which the distal end of the tube is situated. Those who have used this tube speak most highly of it and consider it is superior to all other types of abdominal drainage.

The Cofferdam Drain.—To construct a cofferdam four Penrose wick drains 12 in. (30 cm.) long are arranged in superimposed pairs on two strips of petroleum-jelly gauze 3 in (7.5 cm.) wide of nearly the same length, laid side by side. On these is placed a half inch drainage tube with two lateral holes cut in its distal end. All these are made into a loose bundle by tying three or four *plain* catgut ligatures around them (*Fig. 1539*). C. G. Lenhart and J. P. Fleming[4] recommend this form of drainage in cases of perforated diverticulitis when the mesocolon is much infiltrated. It is also useful in certain cases of tubo-ovarian abscess, and occasionally in a pelvic appendix abscess too high to drain into the rectum or by posterior colpotomy. In the case of perforated diverticulitis the cofferdam is placed on the medial side of the colon, care being taken to allow the bowel to rest upon the four Penrose elements. The drains are removed as follows on the 5th day the tube is taken out; on the 6th, 7th, 8th, and 9th days one Penrose drain is removed and on the subsequent two days a petroleum-jelly gauze strip is withdrawn.

Fig. 1539.—Construction of a cofferdam. (*After C. G. Lenhart and J. P. Fleming.*)

ACUTE APPENDICITIS AND CONDITIONS SIMULATING ACUTE APPENDICITIS

Never bend to the concept of the evils of a pocket of pus between the ligature and the purse-string suture used to invaginate the stump of the appendix. A few surgeons omit the ligature, and trust the purse-string suture to accomplish all. By ill luck, Willard Bartlett,[5] of St. Louis, who always employs the ligature entrusted his son who had acute appendicitis to the care of a surgeon who believed in no ligature on the appendix stump. The boy nearly died of bright red hemorrhage *per rectum*.

Left-sided Appendicitis.—*Situs inversus viscerum totum* a congenital abnormality where there is complete transposition of thoracic and abdominal viscera, occurs once in 35,000 individuals and is more common in males. In such cases, of course the vermiform appendix is situated on the left as it is also in some cases of non-rotation of the mid-gut. What is important to know is that despite the position of the appendix on the left the pain and tenderness of acute left-sided appendicitis are situated on the right. The explanation of the paradoxical phenomenon is unknown. Through lack of this knowledge, in spite of the fact that the apex beat was situated on the right the operation for removal of an acutely inflamed left-sided appendix has, in almost every instance, been unduly prolonged and complicated because a right-sided incision was made. At least 100 cases of left-sided acute appendicitis have been reported. (Bailey and Love[6] S. H. Giorlando.[7])

Acute Appendicitis in Infants.—The error to avoid is to fail to entertain the possibility of acute appendicitis in the presence of acute respiratory infection, one of the exanthemata, or

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[1] Cronin K., personal communication.
[2] Supplied by E. O. Pratt Co. Los Angeles.
[3] Chaffin R. C., *J. int. Coll. Surg.*, 1954 22, 663.
[4] Lenhart C. G., and Fleming, J. P. *Ibid.*, 1953, 19 135
[5] Bartlett Willard *Trans west surg Assoc.* Inc., Chicago 1930 64 69
[6] Bailey Hamilton and Love, R. J. McNeill, *A Short Practice of Surgery* 11th ed. 1958, London; H. K. Lewis.
[7] Giorlando S. W., N. J. *State J. Med.*, 1957 57 948

gastro-enteritis. Regarding the latter there is a special group of cases of appendicitis associated with enteritis in which *Pseudomonas aeruginosa* is the predominating organism. Perforation occurs in over 80 per cent of patients with acute appendicitis under the age of 3 years. It is therefore inadvisable to attempt delayed treatment in patients under this age except in the presence of unusually severe coexisting disease.

Pre-operative Hypothermia for Children with Acute Appendicitis Accompanied by a Very High Temperature.—In a series of 99 patients with acute appendicitis admitted to the Los Angeles Children's Hospital, 44 had a temperature of 102.8° F (39° C.) or more. In 9 of these the temperature did not fall as a result of the usual pre-operative measures for acute appendicitis. The dangers of operating upon a child with considerable pyrexia include ether convulsions, circulatory failure and hyperpyrexia. Therefore, *when the temperature fails to fall* as a result of the usual pre-operative treatment D. Brayton[1] employs hypothermia. The child receives a small dose of a barbiturate, an opiate and scopolamine—small, because hypnotic drugs tend to depress hypothalamic function, decrease the moisture loss in respiration, and consequently raise the body temperature. Anaesthesia is induced with thiopentone and maintained with endotracheal cyclopropane. A thermometer is placed in the rectum. The child is surrounded by plastic bags

Fig. 1540.—Child, aged 4, with acute appendicitis and a high temperature undergoing hypothermia. (*D. Brayton and G. B. Lewis.*)

containing ice-cubes (*Fig.* 1540). Sufficiently deep anaesthesia is induced to control shivering. When the pulse-rate has fallen to 100 per minute (usually in about an hour) the temperature registers about 90° F (32.3° C.) (*Fig.* 1541), and this has been found in practice to be the optimum temperature. The ice-bags are removed and the patient is made ready for operation. The immediate post-operative treatment does not vary from the usual.

[This section has been included at the request of a surgeon who found the method valuable. I would counsel against its use unless the child has some other condition contributing to the pyrexia, in addition to acute appendicitis, in which event it would be better to omit inhalation anaesthesia altogether.—H. B.]

In infants with acute appendicitis, the incidence of co-existing febrile disease, e.g., measles, chicken-pox, acute nasopharyngitis, and acute gastro-enteritis, is remarkably high. Such was present in 14 out of 38 consecutive cases reported by I. A. Fields et al.[3] The mortality of acute appendicitis in infants (at least 10 per cent) remains much higher than the overall mortality-rate (comprising all ages). In the case of infants, no reduction in this rate has been observed since the introduction of antibiotics (J. M. Dean).[4]

Incidentally Brayton believes that when in doubt drain the peritoneal cavity. Drainage was employed in 22 per cent of patients in the above series.

Acute Appendicitis in Pregnancy.—When appendicectomy is undertaken, the patient should be tilted on to her left side. A gridiron incision is recommended; the more advanced the pregnancy, the higher the incision, the level of the incision being determined by the level of the fundus of the uterus.

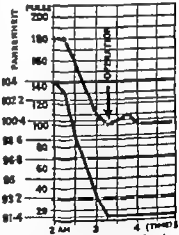

Fig. 1541.—Chart showing the result of hypothermia. (*After D. Brayton and G. B. Lewis.*)

Acute appendicitis carries a general maternal mortality of over 20 per cent in the last trimester of pregnancy—ten times higher than in the first trimester.

R. B. Parker[5] gives details of 6 cases of acute appendicitis late in pregnancy. In no case was the infection localized. Many previous workers have commented on the fact that the peritonitis in these circumstances is almost always diffuse, and the following explanations have been offered. The main responsible factor is considerable upward displacement of the vermiform appendix during

[1] Brayton, D., *Calif. Med.*, 1956, 85, 92.
[2] — — and Lewis, C. B., *Ann. Surg.*, 1957, 145, 804.
[3] Fields, I. A., et al., *A.M.A. J. Dis. Child.*, 1957, 93, 287.
[4] Dean, J. M., *Ann. Surg.*, 1952, 136, 243.
[5] Parker, R. B., *Lancet*, 1954, 1, 1252.

P F Early [1] reporting a case of jejunogastric intussusception following a Polya partial gastrectomy eleven years previously records that the gastric aspirate did not become blood-stained until 34 hours after the onset of symptoms.

The mortality of cases of jejunogastric intussusception not subjected to operation approaches 100 per cent and like all cases of intussusception, the earlier the operation the more favourable the outlook. After reduction (or resection) of the intussusception no other procedure is required. Recurrence in cases complicating partial gastrectomy has not been reported.

Obstruction to the Afferent Loop after Polya Gastrectomy.—Distension of the duodenal stump due to obstruction of the afferent jejunal loop is a potent source of rupture of the duodenal stump. In a retrospective examination of the notes of eight cases of duodenal stump leakage G. F Henson[2] found that with the exception of one early rupture associated with inadequate closure, all patients exhibited slight but definite signs of some preliminary disorder before actual leakage commenced the most constant finding being abdominal pain or discomfort associated with a rise in pulse-rate. There was no record of radiography of the abdomen save in one case, and in this instance the radiographs were taken after the duodenal stump had ruptured.

The value of early radiographic examination of the abdomen in patients with untoward symptoms following partial gastrectomy is stressed by Henson. He gives details of a case where a plain radiograph showed a gas-filled loop of bowel in which valvulae conniventes could just be detected, and on these grounds obstruction of the afferent loop was diagnosed. The abdomen was reopened and an entero-anastomosis was effected between the afferent and efferent loops. It seems likely that unrelieved the obstruction would have proceeded to rupture of the duodenal stump.

Fig 1544.—Volvulus of the stomach leading to obstruction of the afferent loop and gangrenous perforation thereof. (*F C Hoyte et al.*)

Afferent Loop Strangulation following Partial Gastrectomy.—A man, aged 47 underwent partial gastrectomy and on the twenty third day he experienced severe pain in the back and left side of the abdomen, which came on with dramatic suddenness. In spite of intravenous fluid therapy his condition deteriorated so rapidly that he appeared to be about to die. As soon as compatible blood was available retrograde intra-arterial transfusion was performed, using the radial artery As a result of this measure his condition improved. The abdomen was opened through a left paramedian incision. A gangrenous patch was seen on a coil of small intestine, which was greatly distended. The centre of the gangrenous patch had given way (*Fig* 1544) Further search revealed that the stomach had undergone volvulus about its long axis, thus kinking the duodenojejunal juncture The stomach was untwisted. The perforation was repaired and invaginated, and the loops were anchored by a few stitches to the parietal peritoneum, in order to maintain a *status quo ante* The patient recovered. (F C. Hoyte et al.[3])

Spontaneous Rupture of the Stomach.—T Mc.W Millar et al.[4] report 2 cases of spontaneous rupture of the stomach, both in female patients aged 71 years. One patient had pyloric stenosis and had refused operation; in the other case the pylorus would not admit a finger Both patients died shortly after admission; in both cases necropsy showed a tear in the lesser curvature. These authors draw attention to a characteristic sign found in cases of spontaneous rupture of the stomach it is subcutaneous emphysema—first detected in the root of the neck and later spreading over the thoracic wall. The sign was present in both these cases. It has been described before on several occasions in connexion with spontaneous rupture of the stomach. A probable cause of the subcutaneous emphysema is an extensive discharge of gas into the extraperitoneal tissues before the peritoneal coat gives way The sign is well known in connexion with rupture of the oesophagus (see p. 742). Spontaneous rupture has occurred in the intrathoracic stomach of a child (H Wallis[5]).

Rupture of the Stomach following Hæmatemesis.—D E. Bolt and W B. Hennessy report 2 fatal cases, both in women, aged 50 and 74 years respectively

HÆMATEMESIS AND MELÆNA

Operative Management.—Often the patient is elderly and very ill the dangers of inhalation of blood are not inconsiderable Therefore N C. Tanner employs local anæsthesia. He opens the upper abdomen through the midline On rare occasions the xiphoid process is removed. When the patient is obese and the ulcer is duodenal the incision is enlarged by making a transverse extension to the right Should an ulcer not be discovered by inspection and palpation of the

[1] Early P F., *Post-grad. med. J.*, 1937 13 103.
[2] Henson G F *Lancet*, 1933 1 683.
Hoyte, F C., et al., *Lancet* 1937 1 103.
[4] Millar, T Mc W., et al., *Brit J Surg.*, 1937 44 518.
[5] Wallis, H., personal communication.
Bolt D E., and Hennessy W B., *Lancet* 1933 2, 485.
[7] Tanner, N C., *Ann R. Coll Surg Engl.*, 1938 22, 30

Of 4 consecutive cases of ducts damaged elsewhere 2 were injured during the course of early operation for acute cholecystitis. (Mustard and Custer [1])

In view of the danger of duct injuries associated with cholecystectomy (*Fig.* 1345) one should seriously consider cholecystostomy as the operation of choice whenever the acute process makes for technical difficulties. A secondary cholecystectomy is a low price to pay for an intact duct system. (R. W. Buxton et al.)

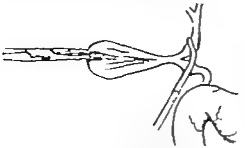

Fig. 1345.—A method by which the main bile ducts are damaged during cholecystectomy

In cases where it is necessary to operate urgently for acute cholecystitis, C. W. Cutler Jun[2] has returned to cholecystostomy even when cholecystectomy appears to be invitingly easy.

After conservative treatment of acute cholecystitis, the best time to operate is 4 to 6 weeks after the acute symptoms have subsided. Following cholecystectomy to administer erythromycin intravenously is an excellent practice for this antibiotic is concentrated in the liver and excreted in the bile in high concentrations.

A New Synthetic Cholagogue.—Zanchol appears to be harmless, and stimulates the flow of bile as observed in patients with a T tube in the common bile-duct. Patients who previously had biliary obstruction, and whose bile was pale yellow in colour soon discharge bile of a brilliant green hue which usually is associated with excellent liver function. (J. M. McGowan.[4])

THE PANCREAS

Hypocalcæmia in Acute Pancreatitis.—R. T. Turner Warwick[4] calls attention to the fact that the serum-calcium level in acute pancreatitis is sometimes reduced to a low level, owing to the formation of calcium-containing fat necroses. A level below 7 mg. per 100 ml. heralds a fatal prognosis. In a man aged 37 weighing 17 st. afflicted with acute pancreatitis, tetany developed, and was relieved by 20 ml. of 10 per cent calcium gluconate given intravenously twice a day. In cases of acute pancreatitis, clearly a serum-calcium estimation should be undertaken several times during the first week if a fall of calcium to a dangerous level is to be prevented regularly.

Delayed Treatment of Acute Pancreatitis.—A constant watch must be maintained for the development of a localized abscess, and this is true particularly if the patient is having a long course of antibiotics that mask the usual signs. Œdema and discoloration of the lumbar region are the most usual presenting signs of a peripancreatic abscess when the lesser sac has not been drained. (R. G. Holt.[7])

INTRA ABDOMINAL INJURIES

Diagnostic Aspiration of Peritoneal Fluid is referred to on pages 203, 214 and 336. In the surgical wards of the Los Angeles General Hospital diagnostic tap has been undertaken in 100 cases of intra-abdominal injury or suspected abdominal injury. Based on this large experience R. V. Byrne[4] reviews the procedure and voices the conclusion of himself and his colleagues in saying that in all cases of suspected intra-abdominal injury in which the symptoms are masked by shock, concussion, hæmorrhage or acute alcoholism, a diagnostic abdominal tap is indicated. The great value of this procedure is that an early diagnosis of a ruptured abdominal viscus can be made in a patient with multiple injuries. A negative tap is valuable in confirming a suspicion of a retroperitoneal injury with the reservation that a negative tap does not always indicate absence of intra-abdominal injury and should the patient's general condition continue to give rise to anxiety a repetition of the diagnostic procedure should be undertaken. As a result of the aspiration, in 81 cases blood or pancreatic or intestinal fluid was recovered and a prompt diagnosis of intra-abdominal rupture was made possible. In 17 cases a negative diagnostic tap resulted in cases where there was, in truth, a ruptured viscus, the diagnosis of which was made on another date. These injuries comprised

Ruptured spleen	8
Ruptured liver	5
Ruptured duodenum	2
Ruptured small intestine	2

[1] Mustard, R. L., and Custer, H. R., *Surg. Gynec. Obstet.*, 1952, 93, 59
[2] Buxton, R. W., et al., *Amer. med. Ass.*, 1951, 146, 301
Cutler, C. W., Jun., *Surg. Clin. N. Amer.*, 1949, 29, 361
[4] G. D. Searle & Co. Ltd., High Wycombe, Bucks.
McGowan, J. M., *Surg. Gynec. Obstet.*, 1956, 103, 163.
Turner-Warwick, R. T., *Lancet*, 1956, 2, 340.
Holt, R. G., *Ann. R. Coll. Surg. Engl.*, 1954, 15, 84
Byrne, R. V., *Surg. Gynec. Obstet.*, 1956, 103, 362.

As is well known, in some cases of a tear of the spleen and also in cases of similar injury to the liver blood-clot seals the rent, or the hemorrhage is subcapsular. These are injuries where delayed intraperitoneal rupture with torrential intraperitoneal hemorrhage is imminent, and often, and quite understandably in the pre-catastrophic stage abdominal tap is negative. Because of early walling-off traumatic perforation of the duodenum and the small intestine is not revealed regularly by an abdominal tap.

The only contra-indication to the tap that has been found after four years' experience is the presence of pronounced abdominal distension.

Contrary to what is advised on page 302, diagnostic aspiration should be made in all four lateral quadrants of the abdomen unless the first, second, or third gives a positive result. The needle recommended is an 18-gauge spinal puncture needle, and it is introduced under local anesthesia.

Technique.—No anesthetic is necessary, but if considered advisable 1 per cent procaine can be used. A snap is felt when the needle passes through the anterior fascia, and another as it passes through the posterior fascia. The peritoneal layer may sometimes be felt as a less pronounced snap. The danger lies, not in introducing the needle into the intestine, but in the aspirated intestinal contents being misinterpreted as peritoneal fluid. W. H. Moretz[1] performed 181 diagnostic peritoneal aspirations with no serious complication. The bowel was entered in 8 (small in 4, and large bowel in 4). S. D. Weakly[2] says that diagnostic abdominal tap is much safer than paracentesis thoracis.

Rupture of the Liver in the Newborn.—In the majority of cases rupture of the liver occurs during normal delivery, i.e., without any obvious trauma to the infant. A subcapsular hæmatoma forms, and gradually enlarges, and if the bleeding does not stop the hæmatoma ruptures through the liver capsule and a great volume of blood pours into the peritoneal cavity. As a rule the diagnosis is not difficult. In J. L. Greaves's[3] patient, as soon as blood transfusion with group O Rh-negative blood was given, improvement set in. Laparotomy was performed and the torn liver was sutured.

Rupture of the Diaphragm.—Severe crushing injuries of the abdomen and the chest account for most cases of rupture of the diaphragm, the ratio of abdominal trauma to thoracic trauma being about 3 to 2. The cause of the injury is sudden increase of intra-abdominal or intra-thoracic pressure.

Fig 1546.—Radiograph of the chest showing a high gastric shadow, collapse of the left lung and fractured ribs. (*K. K. Sinha.*)

Most ruptures are of the left leaf of the diaphragm, the right being protected by the liver. As a rule the rupture extends from near the œsophageal hiatus, across the cupola, towards the costal margin. If the rupture is large abdominal viscera, especially the stomach, often pass into the pleural cavity. It is to this that most of the symptoms are attributable and abnormalities of percussion and auscultation of the chest and occasional bowel-sounds heard through the chest wall help to suggest the diagnosis of this rather infrequent accident. A radiograph of the thorax shows absence of the diaphragmatic shadow on the affected side, partial collapse of the left lung, a pneumothorax, together with abnormal shadows of gas and fluid possibly within the viscus (*Fig* 1546). While laparotomy is often required in order to attend to a ruptured spleen and/or to examine the abdominal viscera, all concur that the ruptured diaphragm can be repaired more effectively through a thoracotomy incision through the bed of the 9th rib than from below. Non-absorbable material should be employed for suturing the diaphragm.

INTESTINAL OBSTRUCTION

Differentiating *Complete* from *Incomplete* Intestinal Obstruction.—Inject 2 oz. (60 ml.) of liquid paraffin down the gastro-intestinal aspiration tube, disconnect the suction and clamp the aspiration tube for three hours. At the expiration of this interval an enema is given and if paraffin is recovered it is obvious that the obstruction is incomplete. (J. A. Hollinger and E. F. Fowler.[7])

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[1] Moretz, W. H., *Amer Surg.*, 1956, 22, 1095.
[2] Weakly, S. D., *Ibid.*, 1957, 23, 802.
[3] Greaves, J. L., *Lancet*, 1955, 2, 127.
[4] Sinha, K. K., *Ibid.*, 1955, 1, 1001.
[5] Harris, F. A., and Sturdy, D. E., *Ibid.*, 1955, 1, 1001.
[6] Wrigley, E. J., *Ibid.*, 1957, 2, 19.
[7] Hollinger, J. A., and Fowler, E. F., *Arch. Surg.*, Chicago, 1953, 66, 888.

Dehydration.—When frank clinical dehydration is present it may be assumed that the patient has lost water equal to 5–7 per cent of his body weight. Since the bulk of the fluid is lost in vomitus, which contains about one-half the concentration of sodium chloride in the plasma, this fraction of body weight should be given, not as normal saline solution (which is often recommended) but as standard dextrose-saline solution. One-half this amount (or approximately 3 per cent of the body weight) can be given safely in the first hour of treatment. (C. Dennis.[1])

The Abuse of Gastro-intestinal Suction Drainage.—Unless Nature is overcoming the obstruction, as announced by the relief of pain and/or the passage of gas from the small to the large intestine as shown by radiography intestinal decompression should not be continued (as a substitute for operation) for more than 24 hours; indeed, in most instances it is safer to reduce this time-limit to 12 hours. Only in this way can many cases of strangulation be brought to light before peritonitis supervenes.

***Cl. Welchii* and the Toxæmia of Intestinal Obstruction.**—Thirty three years ago B. Williams propounded the hypothesis that the toxæmia of acute intestinal obstruction was due to the absorption of toxins of *Cl. Welchii* from the contents of the obstructed intestine. In spite of the fact that the toxin was not isolated from obstructed intestinal contents, Williams and others claimed a substantial reduction in the mortality through the use of *Cl. Welchii* antitoxin as an accessory measure in the treatment of intestinal obstruction. This theory and the treatment by *Cl. Welchii* antitoxin, fell into decline. Lately it has been revivified, at least on a small scale. M. H. Gleeson White and J. J. Bullen[2] have isolated *Cl. Welchii* type D and also *Cl. Welchii* epsilon toxin from the intestinal contents of a patient who died from acute obstruction of the small intestine.

Suction-deflation of Distended Intestine at Operation.—It should be noted that the objective is to remove the gaseous, as opposed to the fluid, contents of the intestine. A. G. R. Lowdon[3] recommends that aspiration is effected through a hollow needle with a diameter of 0·7–0·9 mm.[4] The selected hollow needle is connected by an easily assembled fitting (*Fig.* 1547) to the tubing of a sterile suction apparatus.

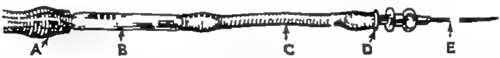

Fig. 1547.—Apparatus for suction-deflation of distended intestine. A, Tubing of suction apparatus; B, Glass connexion; C, Compressible tubing; D, Metal fitting to accommodate hollow needle; E, Needle S.W.G. 20. (*After A. G. R. Lowdon.*)

Technique of Puncturing Intestine.—It is often advisable to aspirate at more than one point, in which case a fresh sterile needle must be employed for each puncture, because after inserting the needle into the bowel it is infected. Therefore should a second puncture be required, the needle is grasped in a hæmostat by its hilt and detached from the apparatus, both the needle and the hæmostat being discarded in favour of a new needle. The needle is inserted through the bowel wall obliquely so that its track passes through the muscular layers for about 0·5 cm. before the submucosa and mucosa are penetrated. As the needle is withdrawn the wall of the bowel is compressed on to the shaft of the needle by a swab moistened with dilute Dettol solution. The swab and the needle are then discarded. In the colon the puncture should be made through a tænial band; whether the punctured intestine be small or large intestine *there is no need to close the puncture with a suture.*

In the colon, almost complete deflation can be obtained, especially when the laparotomy incision is large enough to permit two punctures—one at the midpoint of the transverse colon and one at the proximal end of the pelvic colon. *Puncture of the cæcum and ascending colon should be avoided* because it involves the additional risk of low vitality of the cæcal wall. When about to aspirate small intestine it is easy to tell by inspection and palpation whether the distension is gaseous or fluid. Care must be taken to keep the point of the needle out of the fluid. If these rules are observed, oblique entry of the small or the large intestine can be effected without danger. The method has been used with complete satisfaction in more than 100 cases.

G. A. Smith's Rapid Method of Peroral Intubation of the Small Intestine.—The method of Smith for intubation of the small intestine allows the surgeon to explore the abdomen of a patient suffering from acute intestinal obstruction within two to four hours after admission, with the intestinal aspiration tube in place and the distension greatly relieved.

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[1] Dennis, C., *J. Amer. med. Ass.*, 1934, 154, 402.
[2] Gleeson White, M. H., and Bullen, J. J., *Lancet*, 1955, 1, 884.
[3] Lowdon, A. G. R., *Ibid.*, 1951, 1, 1103; and personal communication.
[4] 0·7 mm. = 22 S.W.G., 0·8 mm. = 21 S.W.G., 0·9 mm. = 20 S.W.G. (the intravenous needle). S.W.G. = Standard wire gauge.

It requires the use of a special flexible stylet with a controllable tip.[1] The stylet (*Fig.* 1548 A), lubricated with petroleum-jelly, is introduced through the hole provided in the side of the tube to a distance of 1 in. (2.5 cm.) from the extremity of the tube. The patient is placed supine on the X-ray couch and the tube, with the stylet in place, is introduced through the mouth into the stomach. The tip, with the stylet, should be inserted into the patient's mouth with the natural curve of the apparatus directed toward the patient's right. A brief flash of the fluoroscopic screen will reveal the location of the tube. If the tube is pointed to the patient's left, it is withdrawn into the cardia, and the stomach is distended with 500–1000 ml. of air and the controllable tip is turned to the right. The stylet and the tube are advanced along the greater curvature until the tube lies in the region of the pylorus. The controllable tip is manipulated until no curve is present. Rotating the tension sleeve of the handle to the right relieves tension on the small wires in the tip. Pressure is exerted on the thumb level to stiffen the stylet and the tube is advanced into the second or third part of the duodenum. The stylet is then extracted 10–13 cm. and the tube is advanced correspondingly. The stylet is again extracted, but the tip of the tube is not advanced. The stylet and the tube are advanced until the tip of the stylet is in the second part of the duodenum. The stylet is then withdrawn completely, the balloon is inflated with 10 ml. of air and the hole in the side of the tube through which the stylet passed is closed with a metal insert. The tubes (the bag is provided with a special small tube for inflation) are advanced 8 cm. each hour; at each time the larger tube is irrigated with 300 ml. of saline solution, which keeps it patent. The proximal end of the tube can be brought through the patient's nose in the manner illustrated in *Fig.* 264. (G. A. Smith.[2, 3])

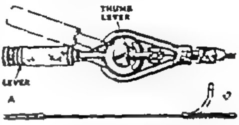

Fig. 1548.—Smith's apparatus for inserting a balloon-ended intestinal tube through the pylorus under radiographic control. A, Stylet.

Intestinal Atresia of the Newborn.—P. P. Rickham[4] finds that the secret of success in dealing with intestinal atresia lies in wide resection of the proximal distended gut. The proximal intestinal loop used for the anastomosis should be of nearly normal calibre. He prefers an end-to-back anastomosis, using one layer of inverting mattress sutures of 4-0 silk on arterial needles. The wide resection of the proximal intestine removes the dilated, hypertrophied, and often partly avascular segment. Infants stand resection, of up to one-third of their small intestine, well.

Intussusception of Infants.—Thirteen cases of intussusception have been reported in patients under one month of age (O. F. Noel and L. A. Beasley, jun.). The presence of slight or moderate pyrexia may mislead the clinician into diagnosing some acute infective condition unless he is aware that pyrexia often occurs in intussusception in infants. (S. E. Reidan.[6])

An intussusception in a baby less than six months of age is more difficult to reduce than one occurring in an older child.

Operation for an Irreducible or Gangrenous Intussusception.—The most expeditious, and probably the best, method of carrying out resection and anastomosis of a gangrenous intussusception in an infant is by Woodhall's[8] ileotransverse colostomy[9] with exteriorization of the divided ends of the ileum and transverse colon. An ileotransverse colostomy is performed 2 in. (5 cm.) from the ends of the divided intestine and the abdominal wall is closed, leaving the clamps and about 1 in. (2.5 cm.) of the ends of the intestine protruding through the upper part of the incision (*Fig.* 1549). If distension occurs, as it often does during the first three or four days, this procedure permits removal of the clamp on the small intestine for a short time, with escape of gas and fluid fæces. After seven days the anastomosis should be functioning satisfactorily and the open wounds of the bowel can be closed extraperitoneally.

Fig. 1549.—Woodhall's operation for gangrenous intussusception.

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[1] Manufactured by George P. Pilling & Sons, Philadelphia, U.S.A.
[2] Smith, G. A., *Surgery*, 1950, **27**, 817.
[3] — *Ibid.*, 1952, **32**, 17.
[4] Rickham, P. P., *Brit. J. clin. Pract.*, 1957, **11**, 683.
[5] Noel, O. F., and Beasley, L. A., jun., *Amer. Surg.*, 1957, **23**, 232.
[6] Reidan, S. E., *Med. World*, 1955, **83**, 313.
[7] Annotation, *Lancet*, 1957, **2**, 132.
[8] Woodhall, B., *Arch. Surg., Chicago*, 1938, **36**, 980.
[9] Zachary, R. B., *Arch. Dis. Child.*, 1955, **30**, 32.

Bolus Obstruction is particularly liable to occur *after partial gastrectomy* [1-8] It will be appreciated readily that after the distal half of the stomach has been removed insufficiently masticated articles of food are liable to be hurried into the small intestine perhaps there to become impacted, whereas normally they would be retained in the stomach until they had become partially digested. Brussels sprouts, green figs, and particularly unmasticated orange pulp have caused intestinal obstruction in these circumstances.

Especially food tuffs that swell e.g., dried fruits swallowed in large lumps (as is likely in edentulous patients), and also articles that are poorly digested in the stomach, e.g. orange pith, can cause obstruction of the small intestine after escaping through a normal pylorus, [11] but a great variety of fruit and vegetables have from time to time been reported as causing bolus obstruction, among them being tomato skins, mango fibres, and a pickled onion.

Treatment.—Timely laparotomy is required. Often there is a considerable quantity of clear free fluid in the peritoneal cavity. An attempt should be made gently to squeeze the bolus onward into the cæcum, and there to break it up by kneading. Should the bolus be impacted so firmly that this manœuvre proves impracticable after isolating the coil with abdominal packs enterostomy is performed. Following piecemeal extraction of the obstructing material, the opening in the intestine is sutured. The loop is mechanically cleansed before returning it to the abdomen, which is then closed.

Cæcostomy.—A. White [13] of Bulawayo, Southern Rhodesia, only exteriorizes the cæcum when there is stercoral ulceration or gangrene. The method he has found admirable is as follows: Through a small gridiron incision the cæcum is deflated by suction-deflation via the terminal ileum close to the ileocæcal valve. The deflated cæcum is delivered, and controlled by a light clamp. The base of the bell of a de Pezzer catheter is cut off so as to provide a wide opening. The catheter is introduced into the cæcum through a small stab incision, and retained in position by two purse-string sutures of catgut provided with eyeless needles. The clamp is removed and the cæcum returned to the abdominal cavity. The incision is closed around the catheter which is anchored to the skin by a silk stitch. By this means the patient can be prepared for an elective resection, even when the neoplasm is as far distal as the pelvic colon. The tube gives watertight drainage for 10 to 14 days. The elective operation is performed within 14 days; the tube is then withdrawn and the orifice closes spontaneously.

Strangulating Obstruction.—In a patient with intestinal obstruction, a sudden onset suggests a *strangulating* obstruction. Palpation of a soggy coil of intestine by bimanual pelvic examination is confirmatory evidence.

Radiographic studies show that a coil of obstructed small intestine in imminent danger of strangulation (if strangulation has not occurred already) is revealed on the film in only 50 per cent of cases. This is no advance on clinical methods, for in 50 per cent of cases such a coil is palpable.

W. F. Becker [14] analysed the notes of 1000 cases of acute intestinal obstruction. He found that in 90 of these strangulation was present or supervened, but was undiagnosed as such for a varying period and gastro-intestinal suction was persisted with for 12 hours or more because of apparent improvement of the patient with this form of treatment; this resulted in death in 40 of these patients. It is highly probable that a great many of these fatalities could have been averted by an earlier operation.

The Value of Antibiotics in Cases of Strangulation.—It is claimed that neomycin will sterilize a segment of intestine in 30 minutes. The survival period in experimental animals with strangulating obstruction is greatly prolonged by the intravenous administration of aureomycin or terramycin. One of these antibiotics should be administered from the time of admission to hospital. (C. Dennis.[15])

Embolectomy for Mesenteric Arterial Occlusion.—Robert S. Shaw of Boston, Massachusetts, has performed superior mesenteric embolectomy for mesenteric arterial occlusion with a successful outcome on two occasions.

Case 1.—A woman, aged 34 with long-standing mitral stenosis with auricular fibrillation, was admitted to the Massachusetts General Hospital complaining of vague abdominal pain

Gall, W. J., *Brit. med. J.*, 1937, 1, 1122.
Colabawalla, B. N., *Ibid.*, 1937, 1, 403.
Corbett, J. T., *Ibid.*, 1937, 1, 824.
Ward-McQuaid, J. N., *Lancet*, 1936, 2, 339.
MacPhee, I. W., *Ibid.*, 1936, 2, 330.
Goodman, L., *Brit. med. J.*, 1937, 1, 764.
Davis, S. L., *Lancet*, 1936, 2, 908.
MacCarthy, D. L., *Ibid.*, 1936, 2, 909.
Cale, Irene S., and Quist, G., *Brit. med. J.*, 1937, 1, 948.
Williams, R. J., *Ibid.*, 1937, 1, 283.
Rowling, J. T., *Lancet*, 1936, 2, 290.
Ross, J. A., *Brit. med. J.*, 19 1, 2, 190.
White, A., personal communication.
Becker, W. F., *Surg. Gynec. Obstet.*, 1933, 96, 677.
Dennis, C., *J. Amer. med. Ass.*, 1934, 154, 403.
Shaw, Robert S., personal communication.

of 15 hours duration, accompanied by vomiting and melæna. The only physical signs were slight abdominal tenderness and subdued peristaltic sounds. Abdominal radiography was unremarkable except that there was rather less than the usual amount of visible gas. She was submitted to laparotomy 23 hours after the onset of symptoms. The entire small intestine was blue-grey in colour and without arterial pulsation. Arteriotomy just distal to an embolus that was palpable in the superior mesenteric artery as it crossed the duodenum, was performed. The colour of the small intestine improved immediately. After a stormy convalescence she recovered. Aortography revealed that the main superior mesenteric artery was patent as also its major branches, but there was occlusion in at least one peripheral radial arcade. A barium meal revealed multiple strictures of the intestine.

Case 2.—The patient was a man, aged 51 who was operated upon 12 hours after the onset of symptoms. The small intestine was blue-black and the transverse colon was also infarcted. Superior mesenteric embolectomy was performed and the transverse colon was exteriorized. Forty-eight hours later the anterior wall of the exteriorized colon became necrotic, but the posterior wall was pink. The patient whose convalescence was delayed by diarrhœa through the colostomy eventually recovered.

Paralytic Ileus.—Most surgeons find difficulty in getting a balloon tipped gastro-intestinal tube past the pylorus when the alimentary tract is immobile. A small stomach tube passed into the intestine is simpler and L. P. Le Quesne[1] says that it is just as effective in preventing further entry of air into the intestine from air swallowing and by its agency sufficient deflation can be achieved to allow recovery of peristalsis. On no account must any measure (administration of an ox-bile or turpentine enema; an injection of carbachol) be taken to endeavour to stimulate peristalsis. Morphine in adequate doses is a drug of the utmost value in this condition.

STRANGULATED HERNIA

Strangulated Inguinal Hernia during Infancy.—During the first year of life the ratio of females to males with a strangulated inguinal hernia is at least 5 : 1. The reason for this astonishing sex disparity is that so frequently it is an ovary that descends into the hernial sac, there to become strangulated. Among 50 examples of strangulated inguinal hernia occurring in females under 12 months of age C. T. Kristiansen and W. H. Snyder[2] found the contents of the sac to be:—

Ovary only	28	Ovary and small intestine	4
Ovary and tube	16	*Small intestine only*	1
Greater omentum	1		

Rarely is it necessary to remove the congested or even a blue-black, ovary. It can be returned to the abdomen where (apparently) often it survives. Oöphorectomy was resorted to only once in the above series.

Irreducible Hernia in Infants.—At the General Infirmary at Leeds, 17 patients with an irreducible inguinal hernia, the oldest being 2 years of age, were suspended by their legs from the foot of the bed or a Balkan beam (judgement of Solomon position) after having been given a sedative (I. Smith[3]). In 18 reduction was effected. Sedatives and suspension effected reduction in 75 per cent of 106 cases at the Boston Children's Hospital (A. Thorndike and C. F. Ferguson[4]). Suspension should never last more than three hours. The advantage of the method over taxis is that there appears to be no danger of gangrenous bowel being replaced.

P. G. McEvedy[5] recorded that 80 per cent of cases of strangulated femoral herniæ arrive in hospital without any diagnosis other than that of intestinal obstruction.

McEvedy's Operation for (Strangulated) Femoral Hernia.—A vertical incision is made over the swelling to 3 in. (7.5 cm.) above the inguinal ligament. In the lower part of the incision the femoral sac is cleared thoroughly. The rest of the incision exposes the inguinal ligament and the rectus sheath. The superficial inguinal ring is identified, and an oblique incision is made over the lower part of the rectus sheath, the incision commencing 1 in. (2.5 cm.) above the superficial ring and running parallel to the lateral border of the rectus muscle (*Fig.* 1530). The direction is

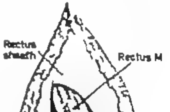

Fig. 1530.—Femoral herniorrhaphy McEvedy approach.

[1] Le Quesne, L. P. *Postgrad. med. J.*, 1957, 33, 600.
[2] Kristiansen, C. T., and Snyder, W. H., *West J. Surg.*, 1956, 64, 481.
[3] Smith, Irvine, *Brit. J. Surg.*, 1954, 42, 271.
[4] Thorndike, A., and Ferguson, C. F., *Amer. J. Surg.*, 1938, 39, 429.
[5] McEvedy, P. G., *Ann. R. Coll. Surg. Engl.*, 1950, 7, 484.

carried down between the transversalis fascia anteriorly and the extraperitoneal tissue posteriorly. In this way the neck of the femoral hernial sac is identified easily as a funnel-shaped structure entering the femoral canal. Attention is now directed to the body and fundus of the sac in the lower part of the wound. After the coverings of the sac have been incised, the sac is opened as described in Lotheissen's operation (see p. 313), and the contents of the sac are dealt with as necessary. Should resection of gut be required, the peritoneum is opened in the upper part of the wound and the released gangrenous segment can be withdrawn on to the surface where there is ample room to carry out resection without hindrance. Having dealt with its contents, the empty sac is freed from the extraperitoneal tissue and the dissection continued until the bladder is identified, the empty sac being withdrawn from the femoral canal into the extraperitoneal space in the upper third of the wound. The sac having been ligated, the loose extraperitoneal tissue is drawn together over it with a stitch. An excellent view of Astley Cooper's (pectineal) ligament is obtained by inserting a Sargent's depressor into the upper part of the wound and retracting the extraperitoneal tissues. The conjoint tendon is sutured to Astley Cooper's ligament with two or three non-absorbable sutures. The subcutaneous tissue should be approximated with interrupted catgut sutures.

This operation, while gaining in popularity, is not performed nearly as frequently as Lotheissen's operation. Its advantage is that if resection is required there is ample room. Its disadvantage is that, especially if the wound becomes infected, it is sometimes followed by a very pronounced ventral hernia. (E. L. Farquharson.[1])

THE RECTUM AND ANAL CANAL

Reactionary Hæmorrhage after Hæmorrhoidectomy is much more common than secondary hæmorrhage. The hæmorrhage may be mainly or entirely concealed, but will become evident on examining the rectum. For its control G. R. Marshall[2] advises the following expedient: a 16 F Foley's catheter provided with a 30-c.c. balloon is inserted through the anus towards the rectal ampulla for 4 in. (10 cm.); proctoscopy is not required for the insertion. The balloon is inflated with either air or water and the inflation tube is clamped. Downward traction is exerted by strapping the catheter to a buttock (*Fig.* 1531) so that pressure is exerted above the anorectal ring. Counter-pressure from below is maintained by means of a perineal pad and a T-bandage. The balloon exerts pressure on the hæmorrhoidal vessels while the catheter permits the escape of flatus or blood, and should bleeding recommence its amount can be observed. Irrigation with 1 oz. (30 ml.) of saline solution from time to time will ensure patency of the catheter. The patient's blood is grouped, and preparations are made for blood transfusion should it be required.

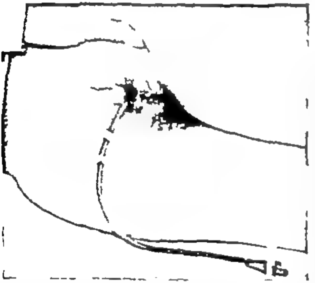

Fig. 1531.—The control of hæmorrhage after hæmorrhoidectomy by traction on an inflated Foley's catheter. (*G. R. Marshall.*)

As a rule the catheter can be dispensed with in 24 hours. Exceptionally the patient must be taken to the operating theatre and the bleeding point secured by under-running it with a ligature on a needle. Should a definite bleeding point not be found, all suspected areas are under-run in this way.

Anorectal Abscess.—In a high percentage of cases (some estimate it at no less than 90 per cent) the abscess commences as an infection of an anal gland. Because the upper branch (there is often only one upper and one lower branch (*Fig.* 1532)) of the anal gland is tubular, it does not become the seat of an abscess so readily as the bulbous-ended inferior branch. In a bacteriological study of 25 cases E. J. Lowell, Jun., found[3]:—

	Per cent		
Esch. coli	60	Streptococci	17
Staphylococci	23	Proteus	11
Bacteroides	20	Diphtheroid	6
Paracolic bacillus	6		

[1] Farquharson, E. L., personal communication.
[2] Marshall, G. R., *J. int. Coll. Surg.*, 1953, 21, 97.
[3] Lowell, E. J., Jun., *Amer. Surg.*, 1953, 21, 189.

In 50 per cent of the patients the infection was mixed In 6 per cent pre- and post-operative blood cultures were found to be positive

On incising an abscess of rapid onset *it is not uncommon to find the abscess contains clotted* blood in addition to pus. This leads to the conclusion that the inflammatory process has eroded a blood-vessel in the wall of the abscess.

S. Eisenhammer[1] has revised the classification of anorectal abscesses (*Fig* 1533). Special attention is directed to (1) high and (2) low intermuscular abscess; (1) has not been described as such before, but as a *submucous abscess (which most certainly it is not)*, while (2) was known as a peri-anal abscess. The other varieties of abscess do not differ from those described in Chapter XLVIII

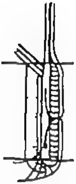

Fig 1532.—An anorectal gland. The upper branch is usually a simple tube

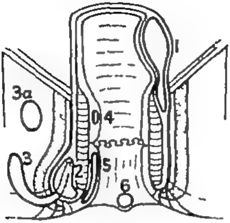

Fig 1533.—Anorectal abscesses 1 High intermuscular; 2, Low intermuscular; 3, Ischiorectal from an extension of (2) 3a, Blood-borne ischiorectal abscess; 4 Submucous abscess; 5, Abscess beneath anal canal skin; 6 Subcutaneous abscess. (*After S Eisenhammer*)

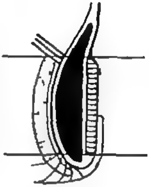

Fig 1534.—Total infection of the intermuscular space (*After S Eisenhammer*)

High Intermuscular Anorectal Abscess (10 per cent) is situated deep to the internal sphincter and occupies the upper part of the intermuscular space. Men between 40 and 55 years of age are the usual sufferers. Constitutional symptoms are pronounced, and the pain that the abscess occasions is considerable. If the pus is not evacuated the abscess either (*a*) bursts into the rectum by penetrating the internal sphincter and overlying mucous membrane, or (*b*) more often spreads to the whole of the intermuscular space (*Fig* 1534), thenceforth to behave like a low intermuscular abscess. The diagnosis is made in the early stages by digital examination of the rectum, when an acutely tender *rounded cystic lump about the size of a walnut is felt above the level of the* dentate line, generally in the posterior quadrant

Treatment.—No time should be lost in evacuating pus in the following manner when the abscess is still high, access to it is obtained by inserting a Sims speculum into the anal canal. A short longitudinal incision is made over the lower border of the internal sphincter (*see Fig* 1532) extending upwards for ½ in. (1 3 cm.) A blunt pointed director is passed deep to the internal sphincter into the abscess cavity and pus flows. The opening is enlarged sufficiently to allow digital exploration. This accomplished, the anoderm is freed bluntly from the internal sphincter *which is divided from below upwards under direct vision on to the director The division is extended* to the uppermost limit of the abscess cavity Bleeding-points, which are not numerous are controlled. No drainage tube is employed.

Low Intermuscular Abscess (60 per cent).—This, the most common abscess of the region, affects persons of all ages. Constitutional symptoms are less pronounced than in the high variety and the pain is less severe. Untreated, frequently the abscess presents subcutaneously near the anal margin.

Treatment.—The principles of treatment differ in no respect from those described above. Should the abscess have implicated the peri-anal skin, it is best excised as described in Chapter XLVIII.

THE UROGENITAL ORGANS

Acute Renal Failure following Surgical Operation or Head Injury—Usually acute renal failure is diagnosed by the sudden onset of signs of renal damage of which the chief are oliguria, proteinuria, low specific gravity and a rising blood-urea level. There is no agreed definition of *oliguria for* diagnostic purposes; the consensus of opinion is to regard 300 ml. a day as the urinary volume

[1] Eisenhammer S., *Surg Gynec. Obstet.*, 1958, 106, 595 and personal communication.

below which there is oliguria. W. H. Taylor[1] recommends that after a serious operation, or a head injury the blood-urea level should be estimated on the second or third day and if it is about 100 mg. per cent the urine urea also should be ascertained. In 31 patients with acute renal failure from one of these two causes, the treatment instituted was restriction of fluid intake (fluid intake was restricted to balance fluid loss), 600–800 ml. being allowed for insensible water loss, and increased by 200 ml. for each degree of temperature above 100° F. (37·7° C.). When the serum-potassium level reached 6·3 mEq. per litre, an attempt to reduce it was made by injecting subcutaneously soluble insulin, 12 units eight-hourly. When the plasma-bicarbonate level fell below 10 mEq. per litre it was raised by intravenous infusion of sodium lactate solution. In the presence of oliguria doses of antibiotics were reduced greatly. The provision of a high-calorie non-protein diet was attempted by mouth or by an indwelling intragastric tube in all patients except those who had undergone an abdominal operation. Ten per cent dextrose solution used alone or with the addition of 5–100 ml. of double-centrifuged cream, proved to be the least nauseating of the diets yet suggested for this purpose. The mortality of acute renal failure in these circumstances is very high. In this series 26 patients died and 5 survived.

Spontaneous Rupture of the Bladder after Partial Cystectomy.[2]—A man, aged 61, admitted to the Royal Infirmary, Huddersfield, in a shocked condition gave the following history. At the cinema that evening he was enjoying the programme. He desired to micturate but did not wish to miss the exciting part of the film; he sat on, and the desire eased. At the end of the performance he went to micturate. Suddenly there was a sharp pain in his lower abdomen; he became intensely shocked and was removed to hospital. Lower laparotomy showed that the scar of the previous operation on the bladder had given way. There was no sign of recurrence of the neoplasm. The bladder was repaired and an indwelling catheter inserted. The patient made an uninterrupted recovery.

Spontaneous Rupture of the Bladder due to Prostatic Obstruction.—G. K. Thomas[3] encountered a case of spontaneous rupture of the bladder in a man aged 70. Six hours previously the patient had a strong desire to micturate but could not do so effectually. The abdomen was a little distended, rigid, very tender and free fluid was detected therein. Laparotomy showed a rupture of the posterosuperior aspect of the fundus of the bladder which admitted three fingers. The prostate was much enlarged, prostatectomy was therefore carried out through the rent which was then repaired. The abdomen was closed with drainage and the patient made a good recovery.

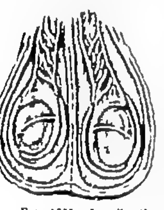

Fig. 1333.—Usually the left testis twists clockwise and the right testis anti-clockwise owing to the spiral attachment of the cremaster muscle prolonged from the internal oblique on to the spermatic cords.

Urethrography in Suspected Rupture of the Urethra.—Umbradil viscous[4] is the best contrast medium for urethrography. It is water soluble, of jelly-like consistency and contains local anæsthetic.

Torsion of the Testis.—A. Wilfrid Adams and N. Slade[5] reaffirm that rotation is encouraged by a lively cremaster and state that it is unlikely that torsion would occur towards the rigid septum dartos, but rather outwards. Thus the left testis usually twists clockwise, and the right anti-clockwise (*Fig.* 1333). In severe twists the total arrest of the spermatic circulation renders ischæmic necrosis of the testis inevitable unless manual detorsion is performed within an hour; as a rule it is only the attending practitioner who has the opportunity to carry out this measure early enough for it to be effective. If a surgeon is confronted with an acute scrotal swelling of uncertain origin, and explores, he will sometimes discover a torsion in which partial ischæmia allows effective untwisting under vision. The necessity for orchidopexy in such cases, as well as anchoring the testis on the contralateral side, is stressed.

Grave Hæmorrhage from the Bladder or from the Prostatic Bed.—W. Müller-Meernach[6] has performed bilateral ligation of the internal iliac artery in 37 cases of severe hæmorrhage from tumours of the bladder. Four additional ligations were performed for serious bleeding after prostatectomy. Fortified by this experience this author has carried out bilateral ligation of the internal iliac arteries in a series of 121 prostatectomies as a preventive measure to serious bleeding. The internal iliac artery is ligated close to its origin from the common iliac artery by the retroperitoneal route. It is reassuring to know that no patient suffered any ill effects attributable to the bilateral ligation.

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[1] TAYLOR, W. H., *Lancet*, 1957, 2, 703.
[2] WALKER, W. F., personal communication.
[3] THOMAS, G. K., *Brit. J. Surg.*, 1956, 44, 328.
[4] Astrapharm Ltd., 8 The Mall, Surbiton, Surrey.
[5] ADAMS, A. W., and SLADE, N., *Brit. med. J.*, 1958, 1, 36.
[6] MÜLLER-MEERNACH, W., *Z. Urol.*, 1956, 49, 74.

ACUTE RETENTION OF URINE

Suprapubic Catheterization with a Foley's Catheter.—J. Swinney[1] has invented a piece of apparatus for introducing a Foley's catheter into a full bladder through a small suprapubic incision. The apparatus consists of a hollow metal tube with a sharp bevelled extremity and it has a longitudinal slit along its whole length. This accommodates the inflation arm of the catheter while the cannula is being withdrawn (*Fig.* 1536 *inset*). *The catheter (size 16 or 20 F.), stretched on a straight metal* introducer, acts as a trocar. The incision is made 6 cm. above the symphysis pubis to the right or left of the middle line. The rectus sheath is incised, and the cannula, held as shown in *Fig.* 1536, is directed downwards, backwards, and slightly inwards, and the bladder is perforated. The straight metal introducer holds the catheter steady during the entry into the bladder of the cannula and the contained catheter.

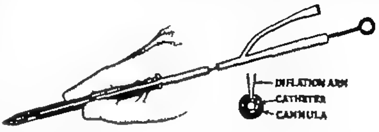

Fig. 1536.—Swinney's suprapubic Foley's catheter introducer.

The metal introducer holding the catheter steadies the latter during the entry into the bladder. The catheter on its introducer is held in position while the cannula is withdrawn. The balloon of the catheter is distended with 10–20 ml. of water and the inflation arm is secured with a ligature as shown in *Fig.* 618, p. 672. The introducer is withdrawn and the catheter is connected to a drainage apparatus. One stitch is sufficient to close the wound about the catheter.

Catheterization of the Urethra by a Fine Calibre Catheter.—N. Gibbon[3] reports that at Walton Hospital, Liverpool, the use of the Gibbon catheter (1.5 mm. portex tubing) (*see Fig.* 590, p. 632) has been extended from cases of neurogenic retention of urine to any cause of retention of urine when long-continued drainage is likely to be required, to wit:—

1. Cases of carcinoma of the prostate when orchiectomy and œstrogen therapy are to be employed in the treatment of the neoplasm in the first instance.
2. Cases of retention of urine due to benign hypertrophy of the prostate when the patient is unfit for early prostatectomy.
3. Stubborn post-operative retention, especially that following extirpation of the rectum. In *the latter retention is anticipated and the catheter is inserted at the close of the operation.*
4. Cases of retention when the urine is known to be infected.

THORAX

Flail Chest (syn. Stove-in Chest).—A crush injury causing multiple fracture of ribs and costal cartilages, producing flail or 'stove-in' chest with its paradoxical movement (*Fig.* 1537), is surprisingly rare. In an eight year period, only 8 cases of this condition were admitted to the Birmingham Accident Hospital (H. Proctor and P. S. London[4]). Only 1 of these 8 patients

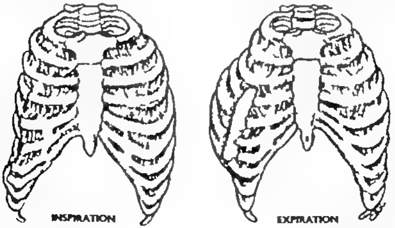

Fig. 1537.—Paradoxical respiration. The comminuted fractured ribs are displaced inwards during inspiration and outwards on expiration or cough. (*After F. P. Coleman and C. L. Coleman.*)

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[1] Swinney, J., *Lancet*, 1957, 2, 28.
[2] Made by Charles F. Thackray Ltd., 10, Park Street, Leeds, 1.
[3] Gibbon, N., *Brit. J. Urol.*, 1958, 30, 1.
[4] Proctor, H., and London, P. S., *Brit. J. Surg.*, 1955, 42, 622.

survived. In this condition there is loss of effective cough with accumulation in the tracheobronchial tree of secretions, which increase the dyspnœa. Increasing dyspnœa results in more pronounced paradoxical movement and rapid deterioration in the patient's general condition. Tracheostomy with repeated suction, will prevent these complications, and of two consecutive patients with a flail chest in whom tracheostomy was carried out soon after admission to hospital, both recovered (S. Hulman[1]). It is important that the tracheostomy should be carried out before the general condition deteriorates and the patient becomes restless, for it is necessary for the patient to lie supine and quite still for a few minutes while the operation is undertaken under local anæsthesia. Tracheostomy breaks the vicious cycle, and produces less paradoxical movement better pulmonary aeration, less pain, less expenditure of energy and easy aspiration of the tracheobronchial tree. In J. A. Rhind's[2] opinion, tracheostomy in these cases has rendered obsolete urgent operation of the screw wire or plate variety.

Fig. 1558.—Fowler's guarded sternal screw.

A. W. Fowler[3] and also J. E. Jacques, while agreeing that tracheostomy is invaluable for symptomatic treatment, emphasize the necessity for adequate stabilization of the floating segment of the chest, be it due to comminuted fractures of the ribs or to fractured sternum. A few nylon sutures inserted blindly around the ribs at the centre of the flapping segment will provide effective stabilization in the case of ribs (Fig. 1559). A. W. Fowler[3] has designed a guarded sternal screw[5] (Fig. 1558). The rib sutures or sternal screw should be attached to weights passing over a pulley.

Fig. 1559.—A method of stabilizing the flail segment by pericostal sutures to which suitable weights are attached. (M. H. J. Richards.)

B. J. Bickford and A. F. Grant recommend displaying the flail area (Fig. 1560) and fixation of the fractures by wiring and in 5 cases there was 1 fatality (uræmia).

Injury to the lung is a common complication of stove-in chest and the possibility of a concomitant hæmothorax should always be considered. Distension of the veins of the neck is indicative of a rise in venous pressure the underlying pathology of which is often compression of the heart by blood, tension pneumothorax, hæmothorax, or mediastinal emphysema. For these reasons F. P. and C. L. Coleman advocate early operation with stabilization of the chest wall by wiring the fractures. As a result of these measures in 15 cases (in each the average number of ribs wired was six) only 2 patients succumbed, both from causes that could not have been accelerated by the method of treatment, viz., delayed rupture of the spleen and crush syndrome.

Fig. 1560.—Typical incision used to display both ends of the fractured ribs.

Oxygen Therapy.—It is absolutely essential that the tongue should be drawn forward when administering oxygen through an endotracheal tube in an unconscious patient.

At a Manchester inquest, a verdict of death by misadventure was recorded in a woman who died of heart failure after an operation. The operation was a short one under general anæsthesia. When she had been returned to bed the ward sister noted that she was cyanosed, and commenced to administer oxygen through an endotracheal tube in the wider nostril; the other was obstructed by mucus. A few seconds later the patient expired. Necropsy revealed that one nasal passage was very narrow indeed due to a broken nose during childhood. Because the tongue had fallen back, obstructing the mouth and the second nostril was blocked, high pressure had been built up by administering oxygen, and both lungs had ruptured.

[1] Hulman, S., Lancet, 1957, 1, 451.
[2] Rhind, J. A., Brit. med. J., 1957, 2, 470.
[3] Fowler, A. W., Ibid., 1957, 2, 592.
[4] Jacques, J. E., Ibid., 1957, 2, 592.
[5] The Zimmer Orthopædic Ltd., Bridgend, Glam.
[6] Bickford, B. J., and Grant, A. F., Ann. R. Coll. Surg. Engl., 1956, 19, 371.
[7] Guetkedjian, N. A., B. R. J. Indust. Med., 1957, 14, 209.
[8] Coleman, F. P., and Coleman, C. L., Surg. Gynec. Obstet., 1950, 90, 129.
[9] Reported in The Lancet, 1957, 2, 1113.

HEAD INJURIES

After a head injury vomiting is common, and the inhalation of gastric juices may lead to death a few hours after the inhalation has taken place. *It is for this reason that the advisory* committee of the North East Metropolitan Regional Hospital Board[1] declares that "The patient should be kept on his side with a clear airway," as is illustrated in *Fig.* 1087 of this book.

A further point of importance is that as soon as practicable the stomach must be emptied and kept empty, for ruptured œsophagus (due to explosive vomiting) is a rare, but potentially disastrous, complication of head injuries, and over 20 examples discovered at necropsy have been reported in the last few years.[2]

The question whether the patient with a serious head injury should be conveyed, if possible, to a neurosurgical centre at a distance is commented upon in no uncertain terms by Professor A. A. McConnell,[3] who writes that there is certainly one type of case that the local surgeon should undertake himself. It is the patient who sustains a head injury without impairment of consciousness, or *with only momentary impairment, who is apparently well for an hour or so, and who then* complains of headache, or vomits, or becomes drowsy, or exhibits any neurological signs. Such a sequence must suggest an extradural hæmorrhage, and there is no time to transfer the patient or summon a neurosurgeon. Many fruitless journeys into the country have convinced him that the local surgeon must assume responsibility for these cases. "May I point out," he says, "that the clinical diagnosis is certain only when the patient is near death, and the only way to make certain before that stage is to make exploratory burr holes."

Obstruction of the Superior Longitudinal Sinus following Closed Head Injuries (Traumatic Hydrocephalus).—J. Purdon Martin[4] describes 3 cases of this condition. Obstruction of a superior longitudinal sinus is usually incomplete and gives rise to two syndromes that occur either separately or in combination. The obstruction of the sinus causes stoppage of the absorption of fluid and a consequent rise of intracranial pressure. In such cases the increased pressure of the intracranial fluid is the same outside and inside the brain, so that no dilatation of the ventricle results therefrom. The first syndrome, which is relatively common, is headache and papillœdema. The second syndrome is a paralytic one, resulting from obstruction and consequent thrombosis of the cortical veins that drain into the sinus. As the affected veins are often those that drain the superior portions of the motor gyri, the resulting signs consist of paralysis of the legs and partial paralysis of the *trunk and upper arms, with sparing of the hands and face.* Convulsions, sometimes of great severity and duration, may accompany the onset.

The treatment of both syndromes is conservative. Martin has had great success with dehydration therapy effected in the early stages by administering magnesium sulphate by rectum. When improvement sets in, and the patient can swallow and retain ingested fluid, the magnesium sulphate is given by mouth. In a case characterized by convulsions, an anticoagulant (tromexan) is prescribed in the hope of preventing further venous thrombosis.

THE NECK

Tracheobronchial Suction via a Tracheostomy.—In order to reduce damage to the mucous membrane, the method of performing tracheobronchial suction devised by F. Plum and M. F. Dunning[5] should be adopted everywhere. *The equipment is simple. A Y tube is intercepted* in the tubing leading from the suction apparatus, and to the distal end of this tubing is attached a No. 12 or 14 whistle-tipped catheter (*Fig.* 1561). When not in use, the catheter is kept in a beaker containing 5 per cent sodium bicarbonate solution, and the nurse must be warned never to employ this catheter for aspiration via the nose. The head is turned to the right to aspirate the left bronchus, and vice versa (*Fig.* 1562). The Y valve is left open during the insertion of the catheter, which is introduced to the full length of the bronchus. The catheter is then withdrawn 1–2 cm., to disengage the tip from the mucous membrane, before the Y-valve is closed with the thumb. Whenever the sound of suction

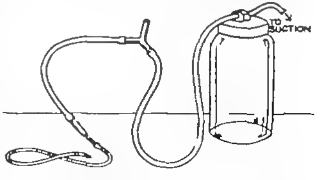

Fig. 1561.—The apparatus for tracheobronchial suction. (*After F. Plum and M. F. Dunning.*)

[1] ANNOTATION, *Lancet*, 1955, 1, 637.
[2] LEADING ARTICLE, *Ibid.*, 1956, 2, 1293.
[3] MCCONNELL, A. A., *Ibid.*, 1957, 1, 481.
[4] MARTIN, J. P., *Brit. med. J.*, 1955, 2, 467.
[5] PLUM, F., and DUNNING, M. F., *New Engl. J. Med.*, 1956, 254, 193.

ceases the vacuum is released by removing the thumb from the Y tube (*Fig* 1503); the catheter is then withdrawn a little before suction is re-applied. After the suction has been completed, the catheter must be removed slowly with a rotary movement, a full circle being effected during withdrawal thumb pressure on the Y valve being released the second that there is any tension on the catheter. Each aspiration should be limited to 15 sec. Unless the secretions are so voluminous as to threaten asphyxia, a rest of 5 min. is allowed between aspirations, so as not to induce hypoxia.

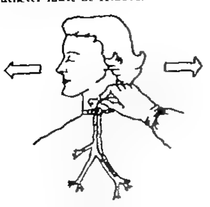

Fig. 1502.—Method of entering each main bronchus. (*After F. Plum and M. F. Dunning.*)

Fig. 1503.—Method of holding the Y tube so that the thumb can start or stop suction at will. (*After F. Plum and M. F. Dunning.*)

Injection of the Stellate Ganglion is referred to on pages 50 and 937. The anterior approach is the most direct and when the ganglion is injected by this route serious complications are most improbable. In a series of 2000 injections by this route, complications were limited to nausea and vomiting from intravascular injection, occasional hoarseness from implication of the recurrent laryngeal nerve and partial paralysis of the upper extremities from overflow on to the brachial plexus; all were transitory as short-acting agents were employed.

The patient lies in the dorsal recumbent position without a pillow and with the neck fully extended *in the middle line*. The site of the skin puncture is two fingerbreadths lateral to the centre point of the sternal notch and two fingerbreadths above the clavicle. This should give the level of the transverse process of the 7th cervical vertebra, and after rotating the head to the contralateral side that the transverse process which is felt is the 7th cervical is checked by (*a*) feeling for Chassaignac's tubercle (*Fig.* 1504) and (*b*) marking the lower border of the cricoid cartilage. The point of puncture is ½ in. (1·25 cm.) below these landmarks, and it is marked on the skin by a ball-pointed pen. The sternomastoid muscle and the carotid sheath are displaced laterally by the fingers, the pulsation of the common carotid artery being felt on the lateral side of the fingers. The needle is inserted and directed posteriorly until it impinges upon the 7th cervical transverse process, at a depth usually not greater than 1½ in. (3·75 cm.). If bone is not encountered, or the patient experiences tingling down the brachial plexus the needle must be withdrawn and directed more medially or slightly upward or slightly downwards, but this is seldom necessary. After impinging upon the transverse process, the needle is withdrawn ⅛ in. (3 mm.) to disengage it from muscle. Aspiration is then undertaken to exclude the possibility of penetration of a blood vessel, and as a double precaution a pause of 15–30 sec. is made after the injection of the first 2 ml. of anæsthetic solution (W. K. J. Walls[1]). Injection into the vertebral artery—a very near relation of the ganglion—is dangerous, since this artery vascularizes the hindbrain and cerebellum. Although it is probable that occasionally the needle passes through a portion of the thyroid gland no sequel from this cause has been noted.

Fig. 1504.—The st. r indicates the sit. t which the palpating left index finger feels Chassaignac tubercle. (*After J. Bonnet.*)

J. Bonnet[2] has found that xylocaine has a more prolonged effect and that this local anæsthetic is less toxic and has a greater penetrating power than procaine. Usually 10 ml. of 1 per cent procaine or xylocaine is employed, but J. Bonnet has often injected 15–20 ml.

Chylous Fistula of the Neck.—Admittedly the occurrence of a cervical chylous fistula is infrequent but the literature on the subject is particularly meagre. The flow of chyle from a complete fistula of the thoracic duct often exceeds 2000 ml. in 24 hours. Weakness, hunger and thirst develop, and in a comparatively short time signs of wasting appear. Inadequately supplemented this loss results in a decrease in the urinary output a weak and rapid pulse-rate and

[1] WALLS, W. K. J., *Brit. J. Anæsth.*, 1953, 27, 616.
[2] BONNET, J., *Arch. Chi. Neerl.*, 1957, 9, 1.

increasing apathy Death from starvation occurs in from 14 days to 8 weeks. Little wonder then, that it was for long believed that wounds of the cervical portion of the thoracic duct were nearly always fatal. Death in the early reported cases was usually caused by inanition and starvation resulting from inadequate nutrition due to the persistent and uncontrolled chylorrhoea.

It is now known that the thoracic duct can be ligated at any level with impunity owing to its numerous collateral communications but a number of erroneous beliefs concerning this condition and its treatment still abound. First and foremost is that it is best to treat the patient conservatively in the hope that spontaneous closure will occur. True spontaneous closure not infrequently ensues, but too often it takes several months, during which time the patient becomes extremely emaciated and requires constant care to prevent death by inanition. Two cases reported by E. S. Judd, jun., and J T Nix[1] required two and ten months respectively for spontaneous closure

Occasionally an operator becomes aware of the accident during the operation by noticing a collection of milky or clear fluid in the wound, which sometimes appears in jets synchronous with expiration. In such cases the cut ends of the duct should be ligated with non-absorbable sutures.

D. P Slaughter and H. W Southwick treated 2 cases successfully by the following method. No anæsthesia was employed because of denervation of the flaps of a block dissection of the neck.

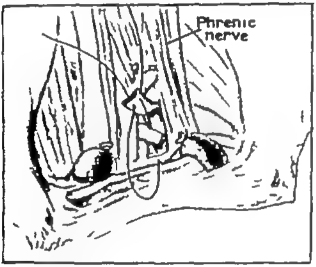

Fig 1563.—Method of ligating a severed thoracic duct The inclusion of the muscle-flap in the ligature is to prevent cutting out at the time of the ligation o what is more common, hours or days later (*After D P Slaughter and H W Southwick*)

The scalenus anticus was split longitudinally to fashion a flap hinged superiorly avoiding the phrenic nerve during the procedure. The flap was incorporated in an occlusive suture of No. 20 cotton, so placed as to encompass the opening of the duct and hold the muscle flap in juxtaposition to the duct (*Fig* 1563), and thus avoid cutting out If the operation is not performed reasonably early the severed duct, bathed in chyle becomes exceedingly friable.

General measures are also of importance. The patient losing chyle should be placed on a low-fat, high-protein diet, and kept strictly at rest Fluid loss must be countered by the intravenous administration of plasma, protein hydrolysate dextrose, and electrolytic solutions. Blood, electrolyte, and protein determinations must be undertaken frequently and any imbalance corrected. (J D Gibson.[3])

Foreign Body in the Pharynx: Perforation of the Common Carotid Artery.—

A woman, aged 51 while eating her dinner felt a lump of meat stick in her throat. She experienced pain in her throat and fearing a fragment of bone might have become lodged, she went to the Casualty Department of the hospital and was reassured. Over the ensuing weeks dysphagia persisted, but became less. Four weeks from the onset she coughed, and bright red blood began to pour from her mouth. She fainted, and was admitted to hospital as a case of ? hæmatemesis, ? hæmoptysis. Following blood transfusion, her condition improved and an ill-defined firm swelling was discovered in the left side of her neck. Under general anæsthesia the pharynx was inspected with a long laryngoscope. A thread-like structure was seen lying against the posterior wall of the hypopharynx. This was grasped with forceps and pulled out. It proved to be a length of thread with a somewhat corroded sewing needle attached. Providentially the needle had remained threaded. (M P Butler[4])

[1] Judd, E. S., jun., and Nix, J T., *Surg Clin. N Amer.*, 1949 29 1035
[2] Slaughter, D P., and Southwick, H. W., *Ann Surg.*, 1955, 142, 207
[3] Gibson, J D., *West. J Surg.*, 1956, 64 247
[4] Butler, M. P., *Lancet* 1956, 1, 141

INTRA-ARTERIAL THIOPENTONE

Intra-arterial Thiopentone —The incidence of this accident is about 1 in 50,000 administrations. In 80 per cent of cases the injection is made into the ulnar artery (*Fig* 1506), which in 8 per cent of individuals is abnormal in that it arises above the level of the elbow joint and is situated more superficially than usual. In 20 per cent of cases the injection has been made into the radial artery which is abnormal in 12 per cent of individuals, in whom it arises higher than usual, and lies superficial, instead of deep, to the deep fascia.

In 24 recorded cases of this accident 9 have been followed by gangrene Of these 6 required amputation of the forearm and the remaining 3 lost one or more digits. (A. C Forrester and R. C O Saunders.[1])

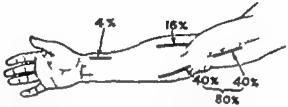

Fig 1506.—Sites of accidental intra-arterial injection of thiopentone recorded in the literature (*After A C Forrester and R. C O Saunders.*)

The first and imperative step is to inject 5 ml. of 2 per cent procaine (or better xylocaine[2] if it is available) into the artery preferably without withdrawing the needle used for the injection of thiopentone The next step is to induce a brachial plexus block, or better a stellate ganglion block (p. 1150). This must be repeated up to 15 days if pallor returns. Stellate ganglion block with 1–1500 solution of cinchocaine when the effect of the first or second procaine or xylocaine block is wearing off will ensure a long-lasting action. The early administration of pethidine by mouth will not only relieve the pain but help to reduce arterial spasm. Whether or not anticoagulant therapy is given depends on whether it is considered advisable to proceed with a cutting operation If no cutting operation is performed, full heparinization is carried out as soon as possible and maintained for four or five days.

PHLEBOTHROMBOSIS

In a post-mortem study of a large number of subjects dying in hospital from various causes, N M Gibbs[3] found the greatest incidence of thrombosis occurred in the intramuscular veins of the soleus muscle (*Fig* 1507). Warning leg signs were discovered in 23 of 100 patients who

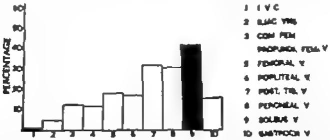

Fig 1507 —Distribution of thrombi within the veins of 4 6 lower limbs (229 cases). Note that the greatest incidence of thrombosis occurs in the intramuscular veins of the soleus muscle (*N M Gibbs The British Journal of Surgery*)

sustained massive pulmonary embolism. Routine leg examinations, if practised would give further increments. (C Crane[4])

In the majority of cases pulmonary embolism commences with phlebothrombosis in the legs. In the legs are two venous systems—the superficial (easy to examine) and the deep. The latter can be examined effectively by oscillometry This simple method applied daily will show clearly by the deviation of the oscillometric needle the existence before or after operation of deep

[1] Forrester, A. C., and Saunders, R. C O., *Brit J Anaesth.*, 1955, 27 504.
[2] Duncan, Flockhart and Co. Ltd., 137 Farringdon Road London, E.C 1
Lignocaine is the approved name of xylocaine
[3] Gibbs N. M., *Brit J Surg.*, 1957 45, 209.
[4] Crane, C *New Engl J Med.*, 1957 257 147

thrombosis of the legs. Pachon's oscillometer (*Fig* 1508) in the opinion of A. Pines,[1] is the best Incidentally oscillometry is the only simple clinical method of defining the mean for effective blood-pressure which is more important than the systolic or diastolic levels. W. Rudowski[2] advises the administration of heparin in amounts of 200 mg daily and states that if the treatment is commenced 6–24 hours after the production of thrombosis further thrombosis will be halted. He also states that if a paravertebral sympathetic block is induced further thrombosis will be prevented, provided the sympathetic block lasts for four days.

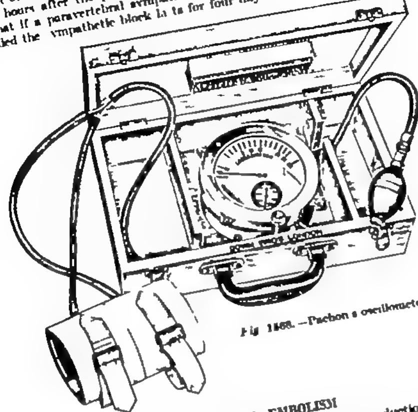

Fig 1508.—Pachon's oscillometer

PULMONARY EMBOLISM

Early ambulation confers many benefits, but the hoped for reduction in the incidence of thrombophlebitis, and consequently of pulmonary embolism (*Fig* 1509), is not one of them. Possibly this is due in some instances to the fact that early ambulation is interpreted as early sitting out of bed—a posture that increases, rather than diminishes, stasis in the veins of the legs.

Fig 1509.—Deaths due to pulmonary embolism. (*After C. Jones.*)

The cause of the increased incidence of pulmonary embolism (pulmonary embolism has become the most common disease of the lungs in a general hospital),[3-5] is not readily apparent. It is suggested that the much longer average time taken over operations is one of them. Another is the extended use of intravenous fluid therapy, in particular when polythene tubing is introduced

[1] Pines, A., *Brit. med. J.*, 1957, 2, 1543.
[2] Rudowski, W., *Ibid.*, 1957, 1, 020.
[3] Israel, H. L., and Goldstein, F., *Ann. intern. Med.*, 1957, 47, 202.
[4] Short, D. S., *Brit. med. J.*, 1952, 1, 790.
[5] McCarthy, H. H., et al., *Arch. Surg., Chicago*, 1957, 75, 408.

far up the vein, where if clotting results, the clot is more likely to become dislodged than when a short metal cannula is employed.

R. W. Wilkins and J. R. Stanton[1] apply elastic stockings to all hospital in-patients under their care with the object of decreasing the calibre of, and increasing velocity through, the deep veins of the legs. A significant reduction in the incidence of pulmonary embolism has occurred thereby. The method is worthy of extensive adoption. On the other hand, W. C. Anlyan and D. Hart compute that 30 per cent of major pulmonary emboli arise from the pelvic and iliac veins, and they draw attention to the frequency of pulmonary embolism after prostatectomy, a condition in which anticoagulants cannot safely be given because of the bleeding they engender. Again, H. Cohen and J. J. Daly[2] describe 10 cases of *unheralded* pulmonary embolism, i.e., none of the patients had signs of peripheral venous thrombosis. A few of the patients were suffering from conditions that favour deep pelvic thrombosis, e.g., one patient was recovering from diathermy coagulation of a papilloma of the bladder; another was suffering from fractured pelvis. Seven of the 10 patients recovered with treatment by anticoagulant therapy.

The symptomatology of pulmonary embolism is at variance with that which has been taught and, forsooth, that which is being taught. From an analysis of a large number of cases, H. L. Israel and F. Goldstein have compiled a table of the leading symptoms and signs, which in round figures are :—

	Per cent
Pyrexia	70
Râles	65
Tachycardia	60
Tachypnœa	45
Hæmoptysis	29
Hypertension	26
Congestive heart failure	24
Friction rub	18

Tachycardia and tachypnœa out of proportion to the pyrexia and pulmonary congestion should always suggest pulmonary embolism. Lack of response to antibiotic therapy helps to confirm this suspicion in doubtful cases of a small embolus.

As a rule there are no radiological signs in the early stages of pulmonary embolism. Stanley Roberts[3] recommends repeated examinations at intervals; often by the second or third day the shadow of the infarct becomes apparent.

J. J. Byrne[3] found that cardiac disease was the most significant factor associated with the combination of venous thrombosis and pulmonary embolism; it was present in 28 per cent of his series of 48 cases of pulmonary embolism.

Pulmonary embolism accounts for 2 to 3 per cent of all deaths in hospital (W. D. Brooks). Although many pulmonary emboli are fatal almost instantly, there are others in which death is delayed for a few hours, and may be averted by treatment. As R. S. Pilcher[3] says, if anything useful is to be done for these patients, the diagnosis must be made and the treatment started at once. In his experience neither pain nor hæmoptysis is to be expected in the early stages after a large pulmonary embolism. The important features of such a case are sudden collapse and signs of obstruction in the right side of the heart. Out of a total of 157 pulmonary embolisms investigated by Pilcher, only 34 were fatal in the first attack. Of the 123 survivors, 10 died as a result of subsequent attack or attacks, thus giving a mortality of 8 per cent in those that survived the initial embolism.

A view with much to support it is that pulmonary embolism is as common in the medical as in the surgical wards. There is no definite sex predominance, and although pulmonary embolism has been recorded at the extremes of life it is commonest between 40 and 60 years of age. Beyond these facts strikingly little can be derived with certainty from vital statistics.

W. C. Anlyan and D. Hart[10] consider that the indications for ligation of the inferior vena cava are :—

1. Recurrent pulmonary embolus, despite anticoagulant therapy.
2. Ditto, anticoagulant therapy contra-indicated.
3. Infective pelvic thrombophlebitis.

Twenty-two out of 23 patients had no further emboli after inferior vena cava ligation.

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[1] WILKINS, R. W., and STANTON, J. R., *New Engl. J. Med.*, 1953, 248, 1087.
ANLYAN, W. C., and HART, D., *Ann. Surg.*, 1957, 146, 499.
[2] COHEN, H., and DALY, J. J., *Brit. med. J.*, 1957, 2, 1209.
ISRAEL, H. L., and GOLDSTEIN, F., *Ann. intern. Med.*, 1957, 47, 202.
[3] ROBERTS, S., *Proc. R. Soc. Med.*, 1957, 50, 93.
BYRNE, J. J., *New Engl. J. Med.*, 1955, 253, 579.
BROOKS, W. D. W., in *Diseases of the Chest* (ed. G. Marshall and K. M. A. Perry), 1952. London.
PILCHER, R. S., *Lancet*, 1956, I, 101.
ANNOTATION, *Ibid.*, 1955, 2, 1376.
[10] ANLYAN, W. C., and HART, D., *Ann. Surg.*, 1957, 146, 499.

At the Peter Bent Brigham Hospital in a six year period 120 patients underwent venous interruption (6 inferior vena cava, the remainder bilateral femoral); 83 of these operations were on account of failure of anticoagulant therapy; others were when bleeding was feared or occurred. (C. Crane [1])

Femoral vein interruption, which can be carried out with very little disturbance even when the patient is very ill, is unpopular in England although in the experience of P. Petch it is the only effective procedure in those cases of recurrent pulmonary embolism from the legs that occur from time to time.

AMPUTATIONS

Amputation in Patients with Vascular Disease.—When an amputation of a lower extremity is to be performed on a patient with advanced arterial disease two fundamental principles must be insisted upon. (1) No tourniquet must be used. (2) Equilateral flaps should be employed, the better to maintain nutrition of the margins of the flaps and to afford dependent drainage, if drainage be considered necessary.

The supracondylar amputation of Reeves and Quattlebaum[3] will be described; the method can be employed equally well for a mid thigh amputation.

The patient is placed on the operating table in a supine position, or even in a semi-Fowler's position if the cardiac condition so demands. The draping of the area and other preliminaries are the same as those described in Chapter LXXXIV. A long sharp-pointed amputation knife is thrust directly backwards into the anterior aspect of the thigh 4–6 in. (10–15 cm.) above the superior border of the patella (*Fig.* 1370 *b*) until its point impinges upon the femur. The point of the knife is then worked around the lateral aspect of the femur and thrust posteriorly until its

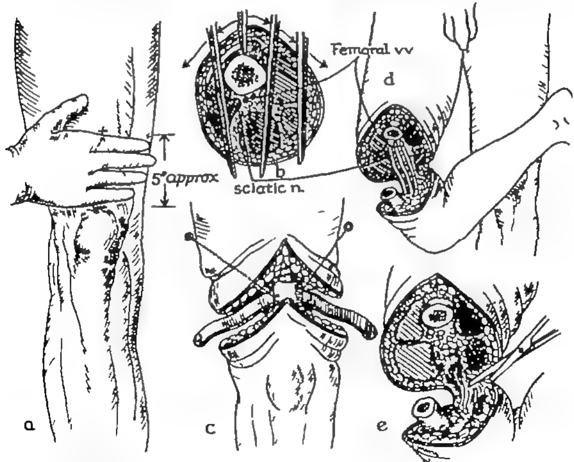

Fig. 1370.—*a*, Site of insertion of long amputation knife; *b*, Method of cutting the two lateral flaps (the femoral vessels and sciatic nerve are protected by the femur); *c*, Severing the bone with a Gigli saw; *d*, Rotation of the flexed leg to dispose the femoral vessels and nerve; *e*, Severing the posterior bridge of fat and skin. (*After M. M. Reeves and F. W. Quattlebaum.*)

[1] Crane, C., *New Engl. J. Med.*, 1957, **257**, 147.
[2] Petch, P., *Lancet*, 1956, 1, 53.
[3] Reeves, M. M., and Quattlebaum, F. W., *Surg. Gynec. Obstet.*, 1956, **102**, 731.

point emerges through the skin as near the midline as possible (*Fig* 1370 *b*). With a to-and-fro movement the blade cuts distally and laterally so that a flap of muscle and skin 2–3 in. (5–7.5 cm.) in length is formed. The blade of the knife is again placed in its original position, and a medial flap of muscle and skin is cut in the same manner. Using a periosteal elevator the muscles are erased from the bone for 1½ in. (3.8 cm.) in an upward direction. A cloth retractor is used to

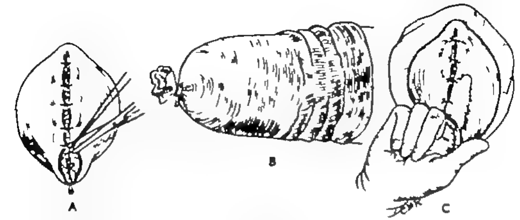

Fig 1571.—A, The lower third of the wound is left unsutured; B, Tubular stockinet fixed to the skin, ready for traction; C, Exploring the wound to evacuate a hematoma or collection of fluid. (*After M. M. Reeves and F. H. Quattlebaum.*)

display the bare bone. A malleable retractor is placed under the femur between the bone and the femoral artery and vein and sciatic nerve. The femur is then transected with a Gigli's saw 1½ in. above the apex of the incision (*Fig* 1370 *c*). The partially detached leg is rotated and flexed to expose the femoral vessels and the sciatic nerve (*Fig* 1370 *d*), which are dealt with in the usual manner. The remaining posterior bridge of tissue (*Fig* 1370 *e*) is divided to complete the amputation. Bleeding vessels are ligated.

At this juncture the cut muscles are viewed critically. Should they appear dusky and ooze but little, poor wound healing is likely to result, and a second amputation is performed immediately at a level approximately 4 in. (10 cm.) higher. Occasionally this must be repeated, until a level of indubitably viable tissue is reached, the criterion being that the muscle is beefy red, and has a goodly capillary ooze. The skin is then approximated in the anterior two-thirds of the incision, the posterior portion being left open for dependent drainage (*Fig* 1571 A). No drain is employed, but a dry dressing is applied.

Skin traction is established by means of tubular stockinet (*Fig* 1571 B), glued to the skin with collodion or one of its substitutes.

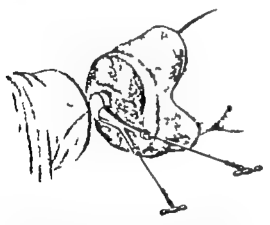

Fig 1572.—The use of a metal bell-end of a stethoscope to protect the soft parts while severing the bone with Gigli's saw. (*After J. Sarnoff.*)

Post-operative Treatment.—For two days traction, by means of a 2 lb. (1 kg.) weight, is employed. In order to evacuate serum, blood, or blood-clot, on the third post-operative day the posterior portion of the wound is explored (*Fig* 1571 C) with a sterile gloved finger as far as the cut end of the femur. This procedure is repeated daily until the wound has healed. During this period the stockinet is retained. If areas of non-viable tissue appear, these are excised.

According to Reeves and Quattlebaum, who have had an enormous experience of this operation, daily dressings of the wound and débridement of non-viable tissue reduces the incidence of infection.

Improvised Guard for a Gigli's Saw.—In order to prevent the Gigli's saw coming into contact with any of the tissues except the bone to be cut, J. Sarnoff[1] uses a metal bell-end of a stethoscope (*Fig* 1572), through which a Gigli's saw can be threaded readily to serve the purpose described. The rapidity with which the bone can be sawn through with the aid of this improvised guard for Gigli's saw is remarkable. The end of the stethoscope helps to steady the bone, guide the saw, retract the soft parts, and guard them from being injured. By holding the guard firmly against

[1] Sarnoff, J., *Ann. Surg.*, 1931, 93, 702.

the bone it is so steadied that the disconcerting to-and-fro motion of the stump ordinarily produced by pulling of the saw is avoided

Femoral Periarterial Sympathectomy for Delayed Healing after Amputation.—In 2 cases of arteriosclerotic gangrene where healing had not followed mid-thigh amputation, periarterial sympathectomy on the femoral artery at a second operation so improved the nutrition of the stump that rapid healing occurred. These cases are a reminder of the occasional usefulness of periarterial sympathectomy—an operation that is usually regarded as out of date (R Clarke and M H Fisher[1])

THE HAND

A large part of the finger denuded of skin.—What to do for the best in these circumstances has been a problem which it would appear has been solved by C R McCash's[2] cross-arm bridge flap the details of which are so clearly depicted in *Fig* 1573 as to render a description superfluous

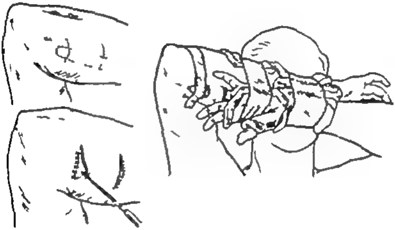

Fig 1573.—The cross-arm bridge flap (*After C R McCash*)

Subungual Haematoma.—A wire paper fastener or a safety pin is straightened out and heated to redness in the flame of a match or a cigarette lighter The glowing point is held against the nail, through which it melts a hole This requires anaesthesia, and A W Ashford injects 1 ml of xylocaine beneath the palmaris longus tendon around the median nerve; this anaesthetizes all the digits except the fifth. The red-hot wire produces a rounded hole through which the blood can be evacuated by pressure Sometimes it is necessary to make two holes (R. P Robertson[3]). It should be noted that once a haematoma beneath a finger or toe-nail clots, evacuation is impossible. Complete clotting occurs in less than 48 hours.

Methods of drilling a hole through the nail, other than that recommended on page 1004 are by means of a dental drill or the electric burr used by chiropodists.

The Ring and the Swollen Finger—Many methods have been devised to remove a ring from a swollen finger For lesser degrees of swelling a little soap and water may suffice.

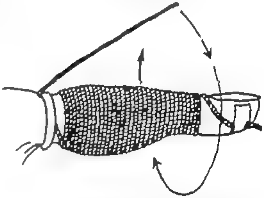

Fig 1574—A method of removing a ring from a swollen finger (*After I J Macpherson.*)

C. A. Birch[4] advises reduction of the swelling by injecting 1000 Benger units of hyaluronidase (hyalase) in 1 ml of procaine into the proximal portion of the swollen area and under the ring on all sides, then massaging gently to spread the injected solution. Should this be unsuccessful, a small aneurysm needle lubricated with soap is passed proximo-distally beneath the ring, and one end of a piece of stout ligature silk or string is drawn beneath the ring to the proximal side The long end of the silk is then wound around the finger as shown in *Fig* 1574 where the distal end of the silk is fixed by a piece of adhesive

[1] Clarke, Ruscoe, and Fisher, M R., *Lancet*, 19.6 1 864
[2] McCash, C. R., *Brit. J plast Surg.*, 1956, 9 25
[3] Ashford A. W., *Ann. Surg.*, 1957 145 287
Robertson R. P., *Lancet* 1957 1 888
Suvarna, R. R., *Ibid.*, 1957 2 97
[4] Birch, C. A., *Brit med. J.*, 1954 2, 503

plaster The proximal end of the silk is then angulated as shown in *Fig* 1374 and rotated around the finger so as to undo the spiral. Provided there is no underlying bony enlargement this method seldom fails. (I J Macqueen.)

In the absence of an aneurysm needle J F Filbee[2] has used with success a large darning needle passed eye first under the ring

An important contra-indication to the method is evidence of sepsis in the affected digit. (R J W Ryder)

SURGICAL EMERGENCIES IN THE TROPICS

Drainage of a Tropical Abscess of the Liver[4]—A number of surgeons find that extrapleural drainage of a posteriorly placed amoebic abscess of the liver gives quicker and better results than aspiration. French surgeons, in particular have found that drainage of an amoebic abscess under antibiotic cover is no longer associated with a higher mortality or morbidity than more conservative measures. A posteriorly situated abscess is drained extrapleurally in a manner similar to the drainage of a subdiaphragmatic abscess (see p. 347). When laparotomy is indicated (central or anteriorly placed abscess of the right lobe and all abscesses of the left lobe) pack impregnated with a solution of erythromycin 1 1000 are so arranged as to isolate the liver The presence of an abscess having been ascertained by needling a trocar and cannula is thrust into the abscess cavity; pus having been evacuated, the cavity is irrigated with saline solution. The opening in the liver is enlarged carefully and a suitably-sized de Pezzer catheter is inserted and anchored to the liver An omental barrier is constructed before closing the abdomen.

After-treatment.—Every effort should be made to keep the drainage closed for as long as possible by connecting the tube to a water-sealed bottle After the operation a full course of specific drug therapy is given, and an antibiotic is administered until the abscess ceases to drain.

THE SURGICAL CORRECTION OF ONE FORM OF NEONATAL RESPIRATORY OBSTRUCTION

Micrognathia. The infant is born with a mandible the horizontal ramus of which is foreshortened. This renders the tongue unduly mobile and results in tongue-swallowing with frequent attacks of dyspnoea and cyanosis especially if a cleft palate is present as well. Attacks of cyanosis in a neonate with the characteristic profile shown in *Fig* 1375 should be sufficient to enable any doctor who has heard of the condition to make a prompt and confident diagnosis.

Fig 1375 Micrognathia A endotracheal tube has been passed. (*Professor A Moncrieff*)

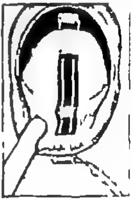

Fig 1376.—Glossolabial fusion. (*After R. Douglas*)

If the infant with this anomaly is permitted to lie on its back, its exitus is not long delayed. To keep an infant in a sitting position day and night for a period of many months throws a strain on the nursing staff, and is rewarded with comparatively scant success. In spite of every care in hospital, when treated conservatively at least 65 per cent of infants with this condition succumb to asphyxia or pneumonia during the first eight weeks of life

The simple operation of glossolabial fusion (*Fig* 1376), whereby a strip of the undersurface of the tongue denuded of its epithelial covering is kept in contact with a strip of the lower lip, bared similarly by a mattress suture for ten days is eminently successful (R. Douglas). The labial muscles soon hypertrophy and eventually assist the tongue in its function of deglutition and articulation.

MACQUEEN, I J., *Brit med. J.*, 1034 2, 471
FILBEE, J F., *Ibid.*, 1034 2, 50.
RYDER, R J W., *Lancet*, 1033 2, 1140.
SCHIFFRO, M M., *Arch. Surg., Chicago* 1036, 73, 700.
DOUGLAS R., *Lyon chir.*, 1030, 32, 420.

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